United States Environmental Protection Agency

Regulatory Impact Analysis for the Industrial Boilers and Process Heaters NESHAP

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Regulatory Impact Analysis for the Industrial Boilers and Process Heaters NESHAP

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Strategies and Standards Division
Innovative Strategies and Economics Group
Research Triangle Park, NC

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Select List of Acronyms and Abbreviations

BOC - Bureau of Census
CAA - Clean Air Act
COPD - Chronic Obstructive Pulmonary Disease
dv - Deciview
DOC - Department of Commerce
DOE - Department of Energy
EIA - Energy Information Administration
EO - Executive Order
EPA - Environmental Protection Agency
FERC- Federal Energy Regulatory Commission
HAP - Hazardous Air Pollutant
ICI - Industrial/Commercial/Institutional
ICR - Information Collection Request
lb - Pound
LDs - Loss Days
LRS - Lower Respiratory Symptoms
MACT - Maximum Achievable Control Technology
mmBtu- million British Thermal Units
NAAQS - National Ambient Air Quality Standards
NAICS - North American Industrial Classification System
NESHAP - National Emission Standards for Hazardous Air Pollutants
NPR - Notice of Proposed Rulemaking
NSPS - New Source Performance Standards
NSR - New Source Review
OMB - Office of Management and Budget
O&M - Operation and Maintenance
PM - Particulate Matter
ppbdv - Parts Per Billion, dry volume
ppm - Parts Per Million
PRA - Paperwork Reduction Act of 1995
RIA - Regulatory Impact Analysis
RFA - Regulatory Flexibility Act
SAB - Science Advisory Board
SBA - Small Business Administration
SBREFA - Small Business Regulatory Enforcement Fairness Act of 1996
SIC - Standard Industrial Classification
SO_2 - Sulfur Dioxide

TAC - Total Annual Cost

tpd - Tons Per Day

tpy - Tons Per Year

UMRA - Unfunded Mandates Reform Act

URS - Upper Respiratory Symptoms

VSL - Value of Statistical Life

VOCs - Volatile Organic Compounds

WLDs - Work Loss Days

EXECUTIVE SUMMARY

EPA is issuing a rule to reduce hazardous air pollutant (HAPs) emissions from existing and new industrial boilers and process heaters that are major sources. This rule is a National Emission Standards for Hazardous Air Pollutants (NESHAP), and will reduce HAP emissions by requiring affected industrial boilers and process heaters to meet emissions limits in order to comply with the Maximum Achievable Control Technology (MACT) floor for these sources. This MACT floor level of control is the minimum level these sources must meet to comply with the rule. The major HAPs whose emissions will be reduced are hydrochloric acid, hydrofluoric acid, arsenic, beryllium, cadmium, and nickel. The rule will also lead to emission reductions of other pollutants such as particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2), and mercury (Hg).

The rule requires emissions reductions necessary to meet the MACT by having affected existing sources comply with emissions limits defined in terms of pound per mmBTU heat input of emissions rate for each HAP. For new sources, the definition for emissions limits is based on the source using the most stringent control technology for reduction of each HAP.

The rule is expected to reduce HAP emissions from existing sources by about 59,000 tons per year by 2005. Of this amount, roughly 43,000 tons is hydrochloric acid, and there is 1,100 tons in reductions of heavy metals such as arsenic, chromium, lead and nickel, among others. The rule is also expected to reduce PM_{10} emissions from existing sources by 560,000 tons per year, and SO_2 emissions from existing sources by 113,000 tons per year by 2005. Hg emissions will be reduced by 1.7 tons per year. The rule will reduce HAP emissions from new sources by about 73 tons in 2005 and PM_{10} emissions by 65 tons in 2005. The annual compliance costs to existing sources, which include the costs of control and monitoring, recordkeeping and reporting requirements, are estimated at $863 million (1999 dollars). For new sources, the annual compliance costs are estimated at $19 million (1999 dollars). The EPA is unable to monetize the benefits of the HAP emissions reductions due to insufficient scientific data, but is able to monetize the benefits of the PM_{10} and SO_2 emissions reductions. The EPA's base estimate of the monetized benefits associated with the rule is $16.3 billion + B (1999 dollars). The estimated difference between monetized benefits and costs for the proposed rule is $15.5 billion + B (1999 dollars). The value of B is the potential value of the large number of unmonetized benefits associated with this rule, including health effects such as reductions in cancer leading to mortality, genotoxicity, liver and kidney damage, and cardiovascular impairment, and welfare effects such as corrosion of materials and crop yield reductions.

There are industries in 43 2-digit Standard Industrial Classification (SIC) codes and 3-digit North American Industrial Classification System (NAICS) that are affected by the rule, but the changes in product price and output are estimated to be no greater than 0.02 percent for any of these affected industries. Effects on energy markets are expected to result in no more than a 0.05 percent in electricity rates, and petroleum and natural gas prices. In addition, coal prices and output will decline overall due to a reduction in coal demand. Based on the energy impacts analysis, the Agency concluded that there is no significant adverse effect on the supply, distribution, and use of energy associated with this rule. While the economic impacts of the above the floor option are also low, the total costs to consumers and producers (the social costs) are more than double those for the final rule.

Of the 576 entities affected by this rule, 185 (or 31 percent) are identified as small entities. Of these small entities, 31 of them have compliance costs of 1 percent of sales or greater, and 10 of these 31 have compliance costs of 3 percent or greater. Based of the relatively low number of small entities affected and the size of the price increases these entities will face, the Agency certifies that there will not be significant impact on a substantial number of small entities (SISNOSE) associated with this rule.

CHAPTER 1

INTRODUCTION AND REGULATORY ALTERNATIVES

The U.S. Environmental Protection Agency (referred to as EPA or the Agency) is developing regulations under Section 112 of the Clean Air Act (CAA, referred to hereafter as the Act) for industrial, commercial and institutional (ICI) boilers and process heaters. These combustion devices are used in the production processes of numerous industries in the U.S. The hazardous air pollutants (HAPs) are generated by the combustion of fossil fuels and biomass in boilers and process heaters. The primary HAPs emitted by ICI boilers and process heaters include arsenic, beryllium, cadmium, lead, hydrochloric acid, mercury, and other HAPs. In addition, ICI boilers and process heaters also emit non-HAP pollutants such as sulfur dioxide and particulate matter. To inform this rulemaking, the Innovative Strategies and Economics Group (ISEG) of EPA's Office of Air Quality Planning and Standards (OAQPS) has developed a regulatory impact analysis (RIA) to estimate the potential impacts of the regulation. This report presents the results of a set of analyses conducted by EPA in order to assess the impacts of the regulation and other alternatives considered by the Agency. Compliance costs, economic impacts, small entity impacts, energy effects impacts, air quality changes, and benefits are included in this RIA.

1.1 Agency Requirements for an RIA

Congress and the Executive Office have imposed statutory and administrative requirements for conducting various analyses to accompany regulatory actions. Section 317 of the CAA specifically requires estimation of the cost and economic impacts for specific regulations and standards proposed under the authority of the Act. In addition, Executive Order (EO) 12866 as amended by EO 13258 requires a more comprehensive analysis of benefits and costs for proposed significant regulatory actions.[1] The Executive Order defines "significant" regulatory action as one that is likely to result in a rule that may:

1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal governments or communities;

2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs, or the rights and obligation of recipients thereof;

4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

Pursuant to the terms of Executive Order 12866 as amended by EO 13258, it has been determined that this rule is a "significant regulatory action" because the annual costs of complying with the rule are expected to exceed $100 million. Consequently, this action was submitted to OMB for review under Executive Order 12866 as amended by EO 13258.

[1] Office of Management and Budget (OMB) guidance under EO 12866 stipulates that a full benefit-cost analysis is required only when the regulatory action has an annual effect on the economy of $100 million or more.

1.1.1 Regulatory Flexibility Act and Small Business Regulatory Enforcement Fairness Act of 1996

The Regulatory Flexibility Act (RFA) of 1980 (PL 96-354) generally requires that agencies conduct a screening analysis to determine whether a regulation adopted through notice-and-comment rulemaking will have a significant impact on a substantial number of small entities (SISNOSE), including small businesses, governments, and organizations. If a regulation will have such an impact, agencies must prepare an Initial Regulatory Flexibility Analysis, and comply with a number of procedural requirements to solicit and consider flexible regulatory options that minimize adverse economic impacts on small entities. Agencies must then prepare a Final Regulatory Flexibility Analysis that provides an analysis of the effect on small entities from consideration of flexible regulatory options. The RFA's analytical and procedural requirements were strengthened by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 to include the formation of a panel if a proposed rule was determined to have a SISNOSE. This panel would be made up of representatives of the EPA, the Small Business Administration (SBA), and OMB.

For reasons explained more fully in Chapter 7 of this RIA and the economic impact analysis for this proposed rule, EPA has determined that there is no SISNOSE for this rule. While there are some impacts to some small firms as estimated in the economic impact analysis, these impacts are not sufficient for a SISNOSE. Therefore, the EPA has not prepared a Regulatory Flexibility Analysis for this rule.

The RFA and SBREFA require the use of definitions of "small entities," including small businesses, governments, and organizations such as non-profits, published by the SBA.[2] Screening analyses of economic impacts presented in Chapter 7 of this RIA examine potential impacts on small entities.

1.1.2 Unfunded Mandates Reform Act of 1995

The Unfunded Mandates Reform Act (UMRA) of 1995 (PL-4) was enacted to focus attention on federal mandates that require other governments and private parties to expend resources without federal funding, to ensure that Congress considers those costs before imposing mandates, and to encourage federal financial assistance for intergovernmental mandates. The Act establishes a number of procedural requirements. The Congressional Budget Office is required to inform Congressional committees about the presence of federal mandates in legislation, and must estimate the total direct costs of mandates in a bill in any of the first five years of a mandate, if the total exceeds $50 million for intergovernmental mandates and $100 million for private-sector mandates.

Section 202 of UMRA directs agencies to provide a qualitative and quantitative assessment (or a "written statement") of the anticipated costs and benefits of a Federal mandate that results in annual expenditures of $100 million or more. The assessment should include costs and benefits to State, local, and tribal governments and the private sector, and identify any disproportionate budgetary impacts. Section 205 of the Act requires agencies to identify and consider alternatives, including the least costly, most cost-effective, or least burdensome alternative that achieves the objectives of the rule.

Since this rule may cause a mandate to the private sector of more than $100 million, EPA did provide an analysis of the impacts of this rule on State and local governments to support compliance with Section 202 of UMRA. A summary of this analysis is in Chapter 6 of this RIA. There are government entities affected by this proposed regulation, and these are primarily municipalities that own industrial boilers that may need to comply.

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[2] Where appropriate, agencies can propose and justify alternative definitions of "small entity." This RIA and the screening analysis for small entities rely on the SBA definitions.

1.1.3 Paperwork Reduction Act of 1995

The Paperwork Reduction Act of 1995 (PRA) requires Federal agencies to be responsible and publicly accountable for reducing the burden of Federal paperwork on the public. EPA has submitted an OMB-83I form, along with a supporting statement, to the OMB in compliance with the PRA. The OMB-83I and the supporting statement explains the need for additional information collection requirements and provides respondent burden estimates for additional paperwork requirements to State and local governments associated with this proposed rule.

1.1.4 Executive Order 12898

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," requires Federal agencies to consider the impact of programs, policies, and activities on minority populations and low-income populations. Disproportionate adverse impacts on these populations should be avoided to the extent possible. According to EPA guidance, agencies are to assess whether minority or low-income populations face risk or exposure to hazards that is significant (as defined by the National Environmental Policy Act) and that "appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group." (EPA, 1996). This guidance outlines EPA's Environmental Justice Strategy and discusses environmental justice issues, concerns, and goals identified by EPA and environmental justice advocates in relation to regulatory actions. The industrial boilers and process heaters rule is expected to provide health and welfare benefits to populations around the United States, regardless of race or income.

1.1.5 Executive Order 13045

Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety Risks," directs Federal agencies developing health and safety standards to include an evaluation of the health and safety effects of the regulations on children. Regulatory actions covered under the Executive Order include rulemakings that are economically significant under Executive Order 12866, and that concern an environmental health risk or safety risk that the agency has reason to believe may disproportionately affect children. EPA has developed internal guidelines for implementing E.O. 13045 (EPA, 1998).

The industrial boilers and process heaters rule is a "significant economic action," because the annual costs are expected to exceed $100 million. Exposure to the HAPs whose emissions will be reduced by this rule are known to affect the health of children and other sensitive populations. However, this rule is not expected to have a disproportionate impact on children.

1.1.6 Executive Order 13211

Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use," was published in the Federal Register on May 22, 2001 (66 FR 28355). This executive order requires Federal Agencies to weigh and consider the effect of regulations on supply, distribution, and use of energy. To comply with this executive order, Federal Agencies are to prepare and submit a "Statement of Energy Effects" for "significant energy actions." The executive order defines "significant energy action" as the following:

1) an action that is a significant regulatory action under Executive Order 12866 or any successor order, and

2) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or

3) that is designated by the Administrator of the Office of Information and Regulatory Affairs as a significant energy action.

An analysis of the effects of this rule on supply, distribution, and use of energy was conducted as part of the economic impact analysis and is summarized in Chapter 7.

1.2 Scope and Purpose of the Regulation

Section 112 of the CAA requires EPA to promulgate regulations for the control of HAP emissions from each source category listed under section 112(c). The statute requires the regulations to reflect the maximum degree of reductions in emissions of HAP that is achievable taking into consideration the cost of achieving emissions reductions, any nonair quality health and environmental impacts, and energy requirements. This level of control is commonly referred to as MACT. The MACT regulation can be based on the emissions reductions achievable through application of measures, processes, methods, systems, or techniques including, but not limited to: (1) reducing the volume of, or eliminating emissions of, such pollutants through process changes, substitutions of materials, or other modifications; (2) enclosing systems or processes to eliminate emissions; (3) collecting, capturing, or treating such pollutants when released from a process, stack, storage or fugitive emission point; (4) design, equipment, work practices, or operational standards as provided in subsection 112(h); or (5) a combination of the above.

For new sources, MACT standards cannot be less stringent than the emission control achieved in practice by the best-controlled similar source. The MACT standards for existing sources can be less stringent than standards for new sources, but they cannot be less stringent than the average emission limitation achieved by the best-performing 12 percent of existing sources for categories and subcategories with 30 or more sources, or the best-performing 5 sources for categories or subcategories with fewer than 30 sources.

In essence, these MACT standards would ensure that all major sources of air toxic emissions achieve the level of control already being achieved by the better-controlled and lower-emitting sources in each category. This approach provides assurance to citizens that each major source of toxic air pollution will be required to effectively control its emissions. A major source of HAP emissions is any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit any single HAP at a rate of 9.07 Mg (10 tons) or more per year or any combination of HAPs at a rate of 22.68 Mg (25 tons) or more a year. At the same time, this approach provides a level economic playing field, ensuring that facilities that employ cleaner processes and good emission controls are not disadvantaged relative to competitors with poorer controls.

1.2.1 Regulatory Background

In September 1996, the EPA chartered the Industrial Combustion Coordinated Rulemaking (ICCR) advisory committee under the Federal Advisory Committee Act (FACA). The committee's objective was to develop recommendations for regulations for several combustion source categories under sections 112 and 129 of the CAA. The ICCR advisory committee, known as the Coordinating Committee, formed Source Work Groups for the various combustion types covered under the ICCR. One of the work groups was formed to research issues related to boilers. Another was formed to research issues related to process heaters. The Boiler and Process Heater Work Groups submitted recommendations, information, and data analysis results to the Coordinating Committee, which in turn considered them and submitted recommendations and information to EPA. The Committee's recommendations were considered by EPA in developing these proposed standards for boilers and process heaters. The Committee's 2-year charter expired in September 1998.

Following the expiration of the ICCR FACA charter, EPA decided to combine boilers with units in the process heater source category covering indirect fired units, and to regulate both under this NESHAP. This was done because indirect fired process heaters and boilers are similar devices, burn similar fuel, have similar emission characteristics, and emissions from each can be controlled using similar control devices or techniques.

1.2.2 Regulatory Authority

Section 112 of the CAA requires that EPA promulgate regulations requiring the control of HAP emissions from major sources and certain area sources. The control of HAP is achieved through promulgation of emission standards under sections 112(d) and (f) and, in appropriate circumstances, work practice standards under section 112(h) of the CAA.

An initial list of categories of major and area sources of HAP selected for regulation in accordance with section 112(c) of the CAA was published in the Federal Register on July 16, 1992 (57 FR 31576). Industrial boilers, commercial and institutional boilers, and process heaters are three of the listed 174 categories of sources. The listing was based on the Administrator’s determination that they may reasonably be anticipated to emit several of the 188 listed HAP in quantities sufficient to designate them as major sources.

This rule affects industrial boilers, institutional and commercial boilers, and process heaters. In this rule process heaters are defined as units in which the combustion gases do not directly come into contact with process gases in the combustion chamber (e.g. indirect fired). Boiler means an enclosed device using controlled flame combustion and having the primary purpose of recovering thermal energy in the form of steam or hot water. A waste heat boiler (or heat recovery steam generator) is a device that recovers normally unused energy and converts it to usable heat. Waste heat boilers are excluded from this rule. A hot water heater is a closed vessel in which water is heated by combustion of gaseous fuel and is withdrawn for use external to the vessel at pressures not exceeding 160 psig. Hot water heaters are excluded from this rule.

Boilers and process heaters emit particulate matter, volatile organic compounds, and hazardous air pollutants, depending on the material burned. Solid and liquid fuel-fired units emit metals, halogenated compounds and organic compounds. Gas fuel-fired units emit mostly organic compounds.

The affected source is each individual industrial, commercial, or institutional boiler or process heater located at a major facility. The affected source does not include units that are municipal waste combustors (40 CFR part 60, subparts AAAA, BBBB or Cb), medical waste incinerators (40 CFR part 60, subpart Ce and Ec), fossil fuel fired electric utility steam generating units, commercial and industrial solid waste incineration units (40 CFR part 60 subparts CCCC or DDDD), recovery boilers or furnaces (40 CFR part 63, subpart MM), or hazardous waste combustion units required to have a permit under section 3005 of the Solid Waste Disposal Act or are subject to 40 CFR part 63, subpart EEE.

The rule applies to an owner or operate a boiler or process heater at a major source meeting the requirements in section II.C. A major source of HAP emissions is any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit any single HAP at a rate of 9.07 Mg (10 tons) or more per year or any combination of HAP at a rate of 22.68 Mg (25 tons) or more a year.

An affected operator must meet the emission limits for the subcategories in Table 1-1 of this preamble for each of the pollutants listed. Emission limits were developed for new and existing sources; and for large, small, and limited use solid, liquid, and gas fuel fired units. Large units are those with heat input capacities greater than 10 MMBtu/hr. Small units are those with heat input capacities less than or equal to 10 MMBtu/hr. Limited use units are those with capacity utilizations less than or equal to 10 percent as required in a federally enforceable permit.

If your new or existing boiler or process heater is permitted to burn a solid fuel, or any combination of solid fuel with liquid or gaseous fuel, the unit is in one of the solid subcategories. If your new or reconstructed boiler or process heater burns a liquid fuel, or a liquid fuel in combination with a gaseous fuel, the unit is in one of the liquid subcategories. If your new or existing boiler or process heater burns a gaseous fuel only, the unit is in the gas subcategory and is not required to meet any emission limit.

Table 1-1. EMISSION LIMITS FOR BOILERS AND PROCESS HEATERS (lb/MMBtu)

Source	Subcategory	PM	or	Total Selected Metals	HCl	Mercury (Hg)	Carbon Monoxide (CO - ppm @3% oxygen)
New Boiler or Process Heater	Solid Fuel, Large Unit	0.04	or	0.00007	0.016	0.0000026	200
	Solid Fuel, Small Unit	0.04	or	0.00007	0.032	0.0000026	--
	Solid Fuel, Limited Use	0.04	or	0.00007	0.032	0.0000026	200
	Liquid Fuel, Large Unit	0.068		--	0.00045		200
	Liquid Fuel, Small Unit	0.068		--	0.0009	--	--
	Liquid Fuel, Limited Use	0.068		--	0.0009	--	200
	Gaseous Fuel, Large Unit	--		--	--	--	200
	Gaseous Fuel, Small Unit	--		--	--	--	
	Gaseous Fuel, Limited Use	--		--	--	--	200
Existing Boiler or Process Heater	Solid Fuel, Large Unit	0.062	or	0.001	0.048	0.000004	--
	Solid Fuel, Small Unit	--		--	--	--	--
	Solid Fuel, Limited Use	0.21	or	0.001	--	--	--
	Liquid Fuel, Large Unit	--		--	--	--	--
	Liquid Fuel, Small Unit	--		--	--	--	--
	Liquid Fuel, Limited Use	--		--	--	--	--
	Gaseous Fuel	--		--	--	--	--

For solid fuel-fired boilers or process heaters, we are allowing sources to choose one of two emission limit options: (1) existing and new affected sources may choose to limit PM emissions to the level listed in Table 1 of this preamble or (2) existing and new affected sources may choose to limit total selected metals emissions to the level listed in Table 1 of the preamble.

If you do not use an add-on control or use an add-on control other than a wet scrubber, you must maintain opacity level to less than or equal to the level established during the compliance test for mercury and PM or total selected metals, and maintain the fuel chlorine content to less than or equal to the operating level established during the HCl compliance test.

If you use a wet scrubber, you must maintain the minimum pH, pressure drop and liquid flowrate above the operating levels established during the performance tests.

If you use a dry scrubber, you must maintain opacity level and the minimum sorbent injection rate established during the performance test.

If you use an ESP in combination with a wet scrubber and cannot monitor the opacity, you must maintain the average secondary current and voltage or total power input established during the performance test.

There is an alternative compliance procedure and operating limit for meeting the total selected metals emission limit option. If you have no control or do not want to take credit of metals reductions with your existing control device, and can show that total metals in the fuel would be less than the metals emission level, then you can monitor the metals fuel analysis to meet the metals emissions limitations. Similarly, if you have no control or do not want to take credit of mercury reduction with your existing control device, and can show that mercury in the fuel would be less than the mercury emission level, then you can monitor the mercury fuel analysis to meet the mercury emission limitations.

1.2.3 Regulatory Alternatives and Control Technologies

1.2.3.1 MACT Floor Development

We considered several approaches to identifying MACT floor for existing industrial, commercial, and institutional boilers and process heaters. First, we considered using emissions data on boilers and process heaters to set the MACT floor. However, after review of the data available, we determined that emissions information was inadequate to set MACT floors. We then considered using State regulations and permits to set the MACT floors. However, we found no State regulations or State permits which specifically limit HAP emissions from these sources.

Consequently, we concluded that the only reasonable approach for determining MACT floors is to base it on control technology. Information was available on the control technologies employed by the population of boilers identified by the EPA. We considered several possible control technologies (i.e., factors that influence emissions), including fuel substitution, process changes and work practices, and add-on control technologies.

We first considered whether fuel switching would be an appropriate control option for sources in each subcategory. Both fuel switching to other fuels used in the subcategory and fuels from other subcategories were considered. This consideration included determining whether switching fuels would achieve lower HAP emissions. A second consideration was whether fuel switching could be technically done on boilers and process heaters in the subcategory considering the existing design of boilers and process heaters. We also considered the availability of the alternative fuel.

After considering these factors, we determined that fuel switching was not an appropriate control technology to be included in determining the MACT floor level of control for any subcategory. This decision was based on the overall effect of fuel switching on HAP emissions, technical and design considerations discussed in section III.A of this preamble, and concerns about fuel availability.

Based on the data available in the emissions database, we determined that while fuel switching from solid fuels to gaseous or liquid fuels would decrease PM and some metals emissions, emissions of some organic HAP would also increase, resulting in uncertain benefits. We determined that it would be inappropriate in a MACT rulemaking, that is technology based, to consider a technology that potentially will result in an increase in a HAP regardless of its potential to reduce other HAP without determining the overall benefit. Determining the benefits of fuel switching would require an assessment of the risk associated which each HAP emitted and a determination of which fuel results in the overall lower risk taking into account the available control technology for each fuel. This assessment will be performed in a future rulemaking.

A similar determination was made when considering fuel switching to "cleaner" fuels within a subcategory. For example, the term "clean coal" refers to coal that is lower in sulfur content and not necessarily lower in HAP content. Data gathered by EPA also indicates that within specific coal types HAP content can vary significantly. Switching to a "clean coal" may increase emissions of some HAP. Therefore, fuel switching to a "cleaner" coal would not be an appropriate option. Fuel switching from coal to biomass would result in similar impacts on HAP emissions. While metallic HAP emissions would be reduced, emissions of organics would increase based on information in the emissions database.

Another factor considered was the availability of alternative fuels. Natural gas pipelines are not available in all regions of the U.S., and natural gas is simply not available as a fuel for many industrial, commercial, and institutional boilers and process heaters. Moreover, even where pipelines provide access to natural gas, supplies of natural gas may not be adequate. For example, it is common practice in cities during winter months (or periods of peak demand) to prioritize natural gas usage for residential areas before industrial usage. Requiring EPA regulated combustion units to switch to natural gas would place an even greater strain on natural gas resources. Consequently, even where pipelines exist some units would not be able to run at normal of full capacity during these times if shortages were to occur. Therefore, under any circumstances, there would be some units that could not comply with a requirement to switch to natural gas.

Similar problems for fuel switching to biomass could arise. Existing sources burning biomass generally are combusting a recovered material from the manufacturing or agriculture process. Industrial, commercial, and institutional facilities that are not associated with the wood products industry or agriculture may not have access to a sufficient supply of biomass materials to replace their fossil fuel.

There are many concerns with switching fuels on sources designed and operated to burn specific fuels. Changes to the fuel type (solid, liquid, or gas) will require extensive changes to the fuel handling and feeding system (e.g., a stoker using wood as fuel would need to be redesigned to handle fuel oil or gaseous fuel). Additionally, burners and combustion chamber designs are generally not capable of handling different fuel types, and generally cannot accommodate increases or decreases in the fuel volume and shape. Design changes to allow different fuel use, in some cases, may reduce the capacity and efficiency of the boiler or process heater. Reduced efficiency may result in a greater degree of incomplete combustion and, thus, an increase in organic HAP emissions. For the reasons discussed above, we decided that fuel switching to "cleaner" solid fuels or to liquid or gaseous fuels would not be appropriate or available as a MACT floor level.

We also determined that using process changes or work practices were not appropriate in developing MACT floors. HAP emissions from boilers and process heaters are primarily dependent upon the composition of the fuel. Fuel dependent HAP are metals, including mercury, and acid gases. Fuel dependent HAP are typically controlled by removing them from the flue gas after combustion. Therefore, they are not affected by the operation of the boiler or process heater. Consequently, process changes would be ineffective in reducing these fuel-related HAP emissions.

On the other hand, organic HAP can be formed from incomplete combustion of the fuel. Data are not available that definitively show that organic HAP emissions are related to the operation of the boiler or process heater. Some studies indicate that organic HAP are greatly influence by time, turbulence and temperature. Other studies indicate that organic HAP emissions are not affected by the operation of the unit. The measurement of CO is generally an indicator of incomplete combustion since CO will burn to carbon dioxide if adequate oxygen is available. Correcting incomplete combustion may be accomplished through providing more combustion air. Therefore, we consider monitoring and maintaining CO emission levels to be associated with minimizing organic HAP emission levels and, thus, CO monitoring would be a good indicator of combustion efficiency and organic HAP emissions.

In summary, we determined that considering process changes and work practices would not be appropriate in developing MACT floors for existing units. We are requesting comment, and information on emission reductions, on whether there are other GCP practices that would be appropriate for minimizing organic HAP emissions from industrial, commercial, and institutional boilers and process heaters.

Consequently, we concluded that add-on control technology is the only factor that significantly controls HAP emissions.

In order to determine the MACT floor based on add-on control technologies, we first examined the population database of existing sources. Units not meeting the definition of an industrial, commercial, or institutional boiler or process heater, and units located at area sources were removed from the database. The remaining units were divided first into three subcategories based on fuel state: gaseous fuel-fired, liquid fuel-fired, and solid fuel-fired units. Each of these three subcategories was then further divided into subcategories based on capacity: (1) large boilers and process heaters (units with heat inputs greater than 10 MMBtu/hr); (2) small units (with a maximum rated heat input capacity of 10 MMBtu/hr or less); and (3) limited use units with capacity utilization less than 10 percent.

We identified the types of air pollution control techniques currently used by existing boilers and process heaters in each subcategory. We ranked those controls according to their effectiveness in removing the different categories of pollutants; including metallic HAP and PM, inorganic HAP such as acid gases, mercury, and organic HAP. The EPA ranked these existing control technologies by incorporating recommendations made by the ICCR, and by reviewing emissions test data, previous EPA studies, and other literature, as well as by using engineering judgement.

Based upon the emissions reduction potential of existing air pollution control techniques, we listed all the boilers and process heaters in the population database in order of decreasing control device effectiveness for each subcategory. Then the technology basis of the existing source MACT floor was determined for each pollutant category by identifying the best-performing 12 percent of units. We then selected the technology used by the median unit in the best performing 12 percent of units (i.e., the boiler or process heater unit representing the 94th percentile) as the technology associated with the MACT floor level of control for each subcategory. As previously described, emissions data for this category is insufficient to identify the best-performing units. The most appropriate way to identify the average emission limitation achieved by the best-performing 12 percent of existing sources is to identify the technology used by the unit in the middle of the range of the best performing 12 percent of units, i.e., the median unit).

After establishing the technology basis for the existing source MACT floor for each subcategory and each type of pollutant, the EPA examined the emissions data available for boilers and process heaters controlled by these technologies to determine achievable emission levels. The resulting emission levels associated with the existing source MACT floors for each pollutant are based on the average of the lowest three run average test data from units using the technology associated with the MACT floor level of control, and by incorporating operational variability using results from multiple tests on these best performing units. This approach reasonably ensures that the emission limit selected as the MACT floor represents a level of control that can be consistently achieved by a unit in the subcategory using the control technology associated with the MACT floor. This approach is reasonable because the most informative way to predict the worst reasonably foreseeable performance of the best-controlled units, with available data, is to examine the available long-term performance of the best performing units that had multiple test results. In other words, the EPA considers all units with the same control technology that is properly designed and operated to be equally well controlled, even if the emission test results from such units vary considerably.

The level of control "achieved" by the average of the top performing 12 percent of units is best represented by the average emissions observed from all units using the same technology as that employed by the unit representing the median of the top 12 percent.

The EPA's review of emissions data indicates that some boilers and process heaters within each subcategory may be able to meet the floor emission levels without using the air pollution control technology that is associated with the MACT floor. This is to be expected, given the variety of fuel types, fuel input rates, and boiler designs included within each subcategory and the resulting variability in emission rates. Thus, for instance, boilers or process heaters within the large unit solid fuel subcategory that burn lower percentages of solid fuels may be able to achieve the emission levels for the large unit solid fuel subcategory without the need for additional control devices.

Furthermore, solid fuels, especially coal, are very heterogeneous and can vary in composition by location. Coal analysis data obtained from the electric utility industry in another rulemaking contained information on the mercury, chlorine, and ash content of various coals. A preliminary review of this data indicate that the composition can vary greatly from location to location, and also within location. Based on the range of variation of mercury, chlorine, and ash content in coal, it is possible for a unit with a lower performing control system to have emission levels lower than a unit considered to be included in the best performing 12 percent of the units.

This situation is reflected in the emissions information used to set the MACT floor emission limits. In some instances there are boilers with ESP's or other controls that achieve similar, or lower, outlet emission levels of non-mercury metallic HAP, PM, or mercury to fabric filters. In most cases, this is due to concentrations entering these other control devices being lower, even though the percent reduction achieved is lower than fabric filters.

Additionally, the design of some control devices may have a substantial effect on the their emission reduction capability. For example, fabric filters are largely insensitive to the physical characteristics of the inlet gas stream. Thus, their design does not vary widely, and emissions reductions are expected to be similar (e.g. 99 percent reduction of PM). However, ESP design can vary significantly.

Consequently, since fuel substitution has been determined not to be an appropriate MACT floor control technology, EPA still considers the fabric filter to be the best-performing control for non-mercury metallic HAPs, PM, and mercury and only emissions information for fabric filters was used to develop emission limits. A detailed discussion of the MACT floor methodology is presented in the memorandum "MACT Floor Analysis for New and Existing Sources in the Industrial, Commercial, and Institutional Boilers and Process Heaters Source Categories" in the docket.

<u>Existing Solid Fuel Boilers and Process Heaters</u> <u>Large Units - Heat Inputs Greater than 10 MMBtu/hr</u>.

The most effective control technologies identified for removing non-mercury metallic HAP and PM are fabric filters. About 14 percent of solid fuel-fired boilers and process heater use fabric filters. Because this is the technology used by the 94th percentile (the median of the best-performing 12 percent), the EPA considers a fabric filter to be the technology basis for the MACT floor for non-mercury metallic HAP control for existing boilers and process heaters in this subcategory.

The most effective control technologies identified for removing inorganic HAP that are acid gases, such as hydrogen chloride, are wet scrubbers and packed bed scrubbers. These technologies are used by about 12 percent of the boilers and process heaters in the solid fuel subcategory. About 10 percent of solid-fired boilers and process heaters use wet scrubbers, and approximately 1 percent use packed bed scrubbers. Because wet scrubbers are the technology used by the 94th percentile (median of the best-performing 12 percent), the EPA considers a wet scrubber to be the technology basis for the MACT floor for acid gas control for existing boilers and process heaters in the solid fuel subcategory. The MACT floor emission level based on wet scrubbers and incorporating operational variability is 0.048 lb HCl/MMBtu.

Based on test information on utility boilers, we have concluded that fabric filters are most effective in controlling mercury, and units having them would constitute the best controlled mercury sources. As discussed previously, more than 6 percent of sources in the subcategory have fabric filters. The MACT floor emission level based on fabric filters and incorporating operational variability is 0.000004 lb mercury/MMBtu.

For organic HAP, we assessed whether maintaining and monitoring CO levels would be part of the MACT floor, and determined that less than 6 percent of the units in this subcategory do so. Therefore, we concluded the MACT floor for existing sources in this subcategory is no emissions reductions for organic HAP.

Therefore, the EPA determined that the combination of fabric filter and wet scrubber control technologies forms the basis for the MACT floor level of control for existing solid fuel boilers or process heaters in this subcategory. We recognize that some boilers and process heaters that use technologies other than those used as the basis of the MACT floor can achieve the MACT floor emission levels. For example, emission test data show that many boilers with well-designed and operated ESP can meet the MACT floor emission levels for non-mercury metallic HAP and PM, even though the floor emission level for these pollutants is based on a fabric filter (however, we would not expect that all units using ESP would be able to meet the rule).

Small Units - Heat Inputs Less than or Equal to 10 MMBtu/hr.

Less than 6 percent of the units in this subcategory used control techniques that would reduce non-mercury metallic HAP and PM, mercury, and inorganic HAP, such as HCl. Also, maintaining and monitoring CO levels was used by less than 6 percent of the units in the subcategory.

Therefore, we determined that the MACT floor emission level for existing units for any of the pollutant categories in this subcategory is no emissions reductions.

Limited Use Units - Capacity Utilizations Less than or Equal to 10 Percent.

The most effective control technologies identified for removing non-mercury metallic HAP and PM are ESP and fabric filters. Less than 2 percent of solid fuel-fired boilers and process heater in this subcategory use fabric filters, and 14 percent use ESP. Because ESP are the technology used by the 94th percentile (the median of the best-performing 12 percent), the EPA considers an ESP to be the technology basis for the MACT floor for non-mercury metallic HAP control for existing boilers and process heaters in the solid fuel subcategory. A PM level is set as a surrogate for non-mercury metallic HAP control. The MACT floor emission level based on ESPs, considering operational variability, is 0.021 lb PM/MMBtu. We are also providing an alternative metals limit of 0.001 lb metals/MMBtu which can be used to show compliance in cases where metal HAP emissions are low in proportion to PM emissions.

Similar control technology analyses were done for the boilers and process heaters in this subcategory for the other pollutant groups of interest, including inorganic HAP, organic HAP and mercury. Less than 6 percent of the units in this subcategory have controls that would reduce emissions of organic HAP, mercury, and inorganic HAP, so the existing source MACT floor for those pollutants is no emissions reductions. Therefore, we determined that ESP control technology, which achieves non-mercury metallic HAP and PM control forms the basis for the MACT floor level of control for existing solid fuel boilers and process heaters in this subcategory.

Existing Liquid Fuel Boilers and Process Heaters

Emissions data for liquid subcategories was inadequate to identify the best-performing sources for reasons described in section D of the preamble. We also found no State regulations or permits which specifically limit HAP emissions from these sources. Therefore, we examined control technology data to identify a MACT floor. We found that less than 6 percent of the units in each of the liquid subcategories used control techniques that would reduce non-mercury metallic HAP and PM, mercury, organic HAP, or inorganic HAP (such as HCl). Therefore, we determined that the control technique associated with the 94th percentile (the median of the best-performing 12 percent) could not be identified.

Therefore, we are unable to identify the best performing 12 percent of units in the subcategories. In light of this analysis, we concluded the MACT floor for existing sources in these liquid subcategory is no emissions reductions for non-mercury metallic HAP, mercury, inorganic HAP, and organic HAP.

Existing Gaseous Fuel Boilers and Process Heaters

Emissions data for gas subcategories was inadequate to identify the best-performing sources for reasons described in section D of the preamble. We also found no State regulations or permits which specifically limit HAP emissions from these sources. Therefore, we examined control technology data to identify a MACT floor. We found that no existing units in the gaseous fuel-fired subcategories were using control technologies that achieve consistently lower emission rates than uncontrolled sources for any of the pollutant groups of interest. Therefore, we are unable to identify the best performing 12 percent of units in the subcategories. Consequently, the EPA determined that no existing source MACT floor based on control technologies could be identified for gaseous fuel-fired units. Therefore, we concluded the MACT floor for existing sources in this subcategory is no emissions reductions for non-mercury metallic HAP, mercury, inorganic HAP, and organic HAP.

1.2.3.2 Consideration of Options Beyond the Floor for Existing Units

Once the MACT floor determinations were done for each subcategory, the EPA considered various regulatory options more stringent than the MACT floor level of control (i.e., technologies or other work practices that could result in lower emissions) for the different subcategories.

Maintaining and monitoring CO levels was identified as a possible control for organic HAPs. However, less than 6 percent of the sources in the existing source subcategories used this control method and it was not considered the MACT floor control technology. We then looked at it as an above-the-floor option. However, information was not available to estimate the HAP emissions reductions that would be associated with CO monitoring and emission limits. This option would also require a high cost to install and operate CO monitors. Given the cost and the uncertain emissions reductions that might be achieved, we chose to not require CO monitoring and emission limits as MACT.

The following sections discuss the above-the-floor options analyzed to control emissions of metallic HAP, mercury, and inorganic HAP. Based on the analysis described in these sections, the EPA decided to not go beyond the MACT floor level of control for the rule for any of the subcategories of existing sources.

Existing Solid Fuel Units

Large Units - Heat Inputs Greater than 10 MMBtu/hr. Besides fuel switching (see section III.D of this preamble), we identified a better designed and operated fabric filter (the MACT floor for new units) as a control technology that could achieve greater emissions reductions of metallic HAP and PM emissions than the MACT floor level of control (i.e., a typical existing fabric filter). Consequently, the EPA analyzed the emissions reductions and additional cost of adopting an emission limit representative of the performance of a unit with a better designed and operated fabric filter. The additional annualized cost to comply with this emission limit was estimated to be approximately 500 million dollars with an additional emission reduction of approximately 100 tons of metallic HAP. The results indicated that while additional emissions reductions would be realized, the costs would be too high to consider it a feasible above the floor option. Non-air quality health, environmental impacts, and energy effects were not significant factors, because there would be little difference in the non-air quality health and environmental impacts of replacing existing fabric filters with improved performance fabric filters. Therefore, we did not select these controls as MACT. Fuel switching was not considered a feasible beyond-the-floor option for the same reasons described in section III.E of the proposal preamble.

We identified packed bed scrubbers as a control technology that could achieve greater emissions reductions of inorganic HAP, like HCl, than the MACT floor level of control (i.e., a wet scrubber). Consequently, the EPA analyzed the emissions reductions and additional cost of adopting an emission limit representative of the performance of a unit with a packed bed scrubber. The additional annualized cost to comply with this emission limit (using a packed bed scrubber) was estimated to be approximately 900 million dollars with an additional emission reduction of approximately 20,000 tons of HCl. The results indicated that while additional emissions reductions would be realized, the costs would be too high to consider it a feasible above the floor option. Non-air quality health, environmental impacts, and energy effects were not significant factors, because there would be little difference in the non-air quality health and environmental impacts between packed bed scrubbers and wet scrubbers. Therefore, we did not select these controls as MACT.

In reviewing potential regulatory options for existing sources, the EPA identified one existing industrial boiler that was using a technology, carbon injection, used in other industries to achieve greater control of mercury emissions than the MACT floor level of control. However, emission data indicated that this unit was not achieving mercury emission reductions. The EPA does not have information that would show carbon injection is effective for reducing mercury emissions from industrial, commercial, and institutional boilers and process heaters. Therefore, carbon injection was not evaluated as a regulatory option.

However, the EPA requests comments on whether carbon injection should be considered as a beyond-the-floor option and whether existing industrial, commercial, or institutional boilers and process heaters could use carbon injection technology, or other control techniques to consistently achieve mercury emission levels that are lower than levels from similar sources with the MACT floor level of control. The EPA is aware that research continues on ways to improve mercury capture by PM controls, sorbent injection, and the development of novel techniques. The EPA requests comment and information on the effectiveness of such control technologies in reducing mercury emissions.

Small Units - Heat Inputs Less than or Equal to 10 MMBtu/hr.

The EPA could not identify a technology-based level of control for the MACT floor for this subcategory. To control non-mercury metallic HAP and mercury, we analyzed the above the floor option of a fabric filter which was identified as the most effective control device for non-mercury metallic HAP and mercury. To control inorganic HAP such as hydrogen chloride, we analyzed the above the floor option of a wet scrubber since it was identified as the least cost option.

The total annualized cost of complying with the fabric filter option was estimated to be $10 million, with an estimated emission reduction of 1.9 tons per year of non-mercury metallic HAP and 0.003 tons of mercury. The annualized cost of complying with the wet scrubber option was estimated to be $11 million, with an emission reduction of 48 per year of HCl. The results of this analysis indicated that while additional emissions reductions could be realized, the costs would be too high to consider them feasible options. Therefore, we did not select these controls as MACT. Non-air quality health, environmental impacts, and energy effects were not significant factors.

Limited Use Units - Capacity Utilizations Less than or Equal to 10 Percent. The MACT floor level of control for this subcategory for non-mercury metallic HAP control is an ESP. Although fabric filters were identified as being more effective, many ESP can achieve similar levels. Any additional emission reduction from using a fabric filter would be minimal and costly considering retrofit costs for existing units that already have ESP. Therefore, an above-the-floor option for metallic HAP was not analyzed in detail, and we did not select fabric filters as MACT. However, an above the floor option of a fabric filter was analyzed for mercury control. The total annualized costs of the fabric filter option was estimated to be an additional $21 million, with an estimated emission reduction of 0.04 tons of mercury.

The EPA could not identify a technology-based level of control for the MACT floor for inorganic HAP in this subcategory. To control inorganic HAP, we analyzed the above-the-floor option of a wet scrubber since it was identified as the least cost option. The total annualized costs of the wet scrubber option was estimated to be $49 million, with an estimated emission reduction of 463 tons per year of HCl.

The results of the above the floor options analyses indicated that while additional emissions reductions could be realized, the costs would be too high to consider them feasible options. Therefore, we did not select these controls as MACT. Non-air quality health, environmental impacts, and energy effects were not significant factors.

Existing Liquid Fuel Units

For the liquid fuel subcategories, the EPA could not identify a technology-based level of control for the MACT floor. For beyond-the-floor options for the liquid subcategory, the EPA identified several PM controls (e.g., fabric filters, electrostatic precipitators, and venturi scrubbers) that would reduce non-mercury metallic HAP emissions. For the above-the-floor analysis, we analyzed the cost and emission reduction of applying a high efficiency PM control device, such as a fabric filter, since these would be more likely to be installed for units firing liquid fuel. We identified wet scrubbers as a technology option beyond the floor for reduction of inorganic HAP, such as HCl. We identified fabric filters as a technology option beyond the floor for reduction of mercury. Consequently, the EPA analyzed the emissions reductions and additional cost of applying high efficiency PM controls and wet scrubbers on liquid fuel-fired units. The additional total annualized cost of a high efficiency PM control device (such as a fabric filter) was estimated to be $460 million, with an additional estimated emission reduction of 1,500 tons per year for non-mercury metallic HAP and 3 tons per year for mercury. The annualized cost of a wet scrubbers was estimated to be an additional $480 million, with an additional HCl reduction of 30 tons per year. The results indicated that while additional emissions reductions would be realized, the costs would be too high to consider them feasible options. Non-air quality health, environmental impacts, and energy effects were not significant factors. Therefore, the EPA chose to not select these controls as MACT for existing liquid units.

Existing Gas-fired Units

For the gaseous fuel subcategories, the EPA could not identify a technology-based level of control for the MACT floor. The great majority, if not all, of the emissions from gas-fired units are organic HAP. As discussed in section III.E of the preamble, CO monitoring and emission limits were considered as an above the floor option but was not selected as MACT given the costs and uncertain reductions achieved. Therefore, no above the floor control technique was analyzed for organic HAPs, and MACT is no emission reduction of non-mercury metallic HAP and mercury, inorganic HAP, and organic HAP.

Fuel Switching as a Beyond-the-floor Option

For the solid fuel and liquid fuel subcategories, fuel switching to natural gas is a regulatory option more stringent than the MACT floor level of control that would reduce mercury, metallic HAP, and inorganic HAP emissions. We determined that fuel switching was not an appropriate above-the-floor option for the reasons discussed in sections III.A and III.D of this proposal preamble. In some cases, organic HAP would be increased by fuel switching. Additionally, the estimated emissions reductions that would be achieved if solid and liquid fuel units switched to natural gas were compared with the estimated cost of converting existing solid fuel and liquid fuel units to fire natural gas. The annualized cost of fuel switching was estimated to be $12 billion. The additional emission reduction associated with it was estimated to be 1,500 tons per year for metallic HAP, 11 tons per year for mercury, and 13,000 tons per year for inorganic HAP. Additional detail on the calculation procedures is provided in the memorandum "Development of Fuel Switching Costs and Emissions reductions for Industrial, Commercial, and Institutional Boilers and Process Heaters" in the docket.

1.2.3.3 EPA Response to Recent Court Decisions in Developing the Emission Limitations

In developing the emission limitations, we tried to be responsive to the recent court decisions from *National Lime Association v. EPA* and *Cement Kiln Recycling Coalition v. EPA*, regarding the methodology used for determining the MACT floor. In response, we determined that the most acceptable and appropriate approach for determining the MACT floor appears to be using only emission data. As discussed and explained in section II.E of the proposal preamble, we determined that for these source categories and the subcategories established the use of only the available emission data would be inappropriate for determining the MACT floor for existing and new units. If only the available emission data (from a population of units that is deemed unrepresentative) is used, the resulting MACT floor emission levels would be, in most many cases, unachievable. This is because the concentration of HAP (metals, HCl, mercury) vary greatly within each fuel type. Some even have fuel analysis levels below the detection limit. Therefore, some units without any add-on controls have emission levels below those with add-on controls. Section III.E of the proposal preamble explains in more detail the approach used to develop the MACT floors for each subcategory and why the approach is appropriate for the subcategories regulated by this rule and why the mandating of fuel choice (using low HAP-containing fuel) is also inappropriate.

In terms of subcategorizing, the main difficulty of establishing a separate subcategory for each specific fuel type is that many industrial boilers burn a combination of fuels. Determining which subcategory applies if the mixture varies would be problematic. Would the applicable emission limits change each time the fuel mixture changes? How would compliance be determine and how would continuous compliance be monitored? Because of these concerns, EPA chose not to further subcategorize sources by each specific fuel type.

However, if we were to further subcategorize solid-fuel units into separate fossil and non-fossil subcategories, we would first determine if the MACT floor could be developed, for either subcategory, based on emissions information. If not, then we would look at developing MACT floors based on control technologies. First we would determine if fuel switching or work practices could be used. Based on the MACT floor analysis for solid-fuel fired boilers, it is expected that emissions information and fuel switching would not be appropriate to develop the MACT floors for a solid fossil or solid non-fossil subcategory. Similarly, there would be an insufficient number of boilers or process heaters that would be meeting CO limits to set a level for existing units. However, new units would likely be subject to a CO limit and monitoring.

In order to determine the MACT floor based on add-on control technologies, we would follow similar procedures described in section III.E of the preamble. We would examine the population database of existing sources and subcategorize solid fossil and non-fossil fuel fired boilers into each of the following three subcategories based on capacity: (1) large boilers and process heaters (units with heat inputs greater than 10 MMBtu/hr); (2) small units (with a maximum rated heat input capacity of 10 MMBtu/hr or less); and (3) limited use units with capacity utilization less than 10 percent.

We would identify the types of air pollution control techniques currently used by existing boilers and process heaters in each subcategory. Then we would rank those controls according to their effectiveness in removing the different categories of pollutants; including metallic HAP and PM, inorganic HAP such as acid gases, mercury, and organic HAP.

Based upon the emissions reduction potential of existing air pollution control techniques, we would list all the boilers and process heaters in the population database in order of decreasing control device effectiveness for each subcategory. Then the technology basis of the existing source MACT floor would be determined for each pollutant category by identifying the best-performing 12 percent of units. We would then selected the technology used by the median unit in the best performing 12 percent of units (i.e., the boiler or process heater unit representing the 94th percentile) as the technology associated with the MACT floor level of control for each subcategory.

After establishing the technology basis for the existing source MACT floor for each subcategory and each type of pollutant, we would examine the emissions data available for boilers and process heaters controlled by these technologies to determine achievable emission levels. The resulting emission levels associated with the existing source MACT floors for each pollutant would be based on the average of the lowest three run average test data from units using the technology associated with the MACT floor level of control, and by incorporating operational variability using results from multiple tests on these best performing units.

The preliminary MACT floor control technology for solid fossil-fuel fired units would be a combination of a fabric filter and a scrubber. The preliminary MACT floor control technology for solid non-fossil-fuel fired units would be a combination of an ESP and a scrubber.

1.2.3.4 How did EPA Determine the Emission Limitations for New Units?

All standards established pursuant to section 112 of the CAA must reflect MACT, the maximum degree of reduction in emissions of air pollutants that the Administrator, taking into consideration the cost of achieving such emissions reductions, and any non-air quality health and environmental impacts and energy requirements, determines is achievable for each category. The

CAA specifies that the degree of reduction in emissions that is deemed achievable for new boilers and process heaters must be at least as stringent as the emissions control that is achieved in practice by the best-controlled similar unit. However, the EPA may not consider costs or other impacts in determining the MACT floor. The EPA may require a control option that is more stringent than the floor (beyond-the-floor) if the Administrator considers the cost, environmental, and energy impacts to be reasonable.

Determining the MACT floor for New Units

Similar to the MACT floor process used for existing units, we considered several approaches to identifying MACT floors for new industrial, commercial, and institutional boilers and process heaters. First, we considered using emissions data on boilers and process heaters to set the MACT floor. However, after review of the data available, we determined that emissions information was inadequate to set MACT floors. We also reviewed State regulations and permits for these sources, but found no State regulations or State permits which specifically limit HAP emissions from industrial, commercial, and institutional boilers and process heaters.

Consequently, we concluded that the only reasonable approach for determining MACT floors is to base it on control technology. Data were available on the control technologies employed by the population of boilers identified by the EPA. We considered several possible control technologies (i.e., factors that influence emissions), including fuel substitution, process changes and work practices, and add-on control technologies.

We first considered whether fuel switching would be an appropriate control option for sources in each subcategory. Both fuel switching to other fuels used in the subcategory and fuels from other subcategories were considered. This consideration included determining whether switching fuels would achieve lower HAP emissions. A second consideration was whether fuel switching could be technically done on boilers and process heaters in the subcategory considering the existing design of boilers and process heaters. We also considered the availability of the alternative fuel.

As discussed in section III.D of the proposal preamble, based on the data available in the emissions database, we determined that while fuel switching would decrease some HAPs, emissions of some organic HAPs would increase, resulting in uncertain benefits. We determined that it would be inappropriate in a MACT rulemaking, that is technology based, to consider a technology that potentially will result in an increase in a HAP regardless of its potential to reduce other HAP without determining the overall benefit. A detailed discussion of the consideration of fuel switching is discussed in proposal preamble section III.D.

We also determined that using process changes or work practices were not appropriate in most cases for developing MACT floors. HAP emissions from boilers and process heaters are primarily dependent upon the composition of the fuel. Fuel dependent HAP are metals, including mercury, and acid gases. Fuel dependent HAP are typically controlled by removing them from the flue gas after combustion. Therefore, they are not affected by the operation of the boiler or process heater. Consequently, process changes would be ineffective in reducing their emissions. The exception to this conclusion is monitoring and maintaining CO levels. The measurement of CO is generally an indicator of incomplete combustion since CO will burn to carbon dioxide if adequate oxygen is available. Correcting incomplete combustion may be accomplished through providing more combustion air. Therefore, we consider monitoring and maintaining CO emission levels to be associated with minimizing organic HAP emission levels and, thus, CO monitoring would be a good indicator of combustion efficiency and organic HAP emissions. As discussed in the final preamble, CO is considered a surrogate for organic HAP emissions in this rule.

To determine if CO monitoring would be the basis of the new source MACT floor for organic emissions control, we examined available information. The population databases did not contain information on existing units monitoring CO emissions. We reviewed State regulations applicable to boilers and process heaters that required the use of CO monitoring to maintain a specific CO limit. The analysis of the State regulations indicated that at least one of the boilers and process heaters in the large and limited use subcategories for solid fuel, liquid fuel, and gaseous fuel were required to monitor CO emissions and meet a CO limit of 200 parts per million. Therefore, the new source MACT floor level of control includes a CO emission limit of 200 parts per million for large and limited use units.

We concluded that, except for CO monitoring for organic HAP, add-on control technology is the only factor that significantly controls emissions. To determine the MACT floor for new sources, the EPA reviewed the population database of existing major sources.

Based upon the emission reduction potential of existing air pollution control devices, the EPA listed all the boilers and process heaters in the population database in order of decreasing control device effectiveness for each subcategory and each type of pollutant. Once the ranking of all existing boilers and process heaters was completed for each subcategory and type of pollutant, the EPA determined the technology basis of the new source MACT floor by identifying the best-controlled source using the air pollution control rankings.

After establishing the technology basis for the new source MACT floor for each subcategory and each type of pollutant, the EPA examined the emissions data available for boilers and process heaters controlled by these technologies to determine achievable emission levels for PM (as a surrogate for non-mercury metallic HAP), total selected non-mercury metallic HAP, mercury, HCl (as a surrogate for inorganic HAP), and CO (as a surrogate for organic HAP). This approach is reasonable because the most informative way to predict the worst reasonably foreseeable performance of the best-controlled unit, with available data, is to examine the performance of other units that use the same technology. In other words, the EPA considers all units with the same control technology to be equally well controlled, and each unit with the best control technology is a "best controlled similar unit" even if the emission test results from such units vary considerably.

Accordingly, we selected as the floor for new units the level of control that was being achieved in practice by the best-controlled similar source, that is, the source with emissions representing the performance of the most effective control technology under the worst reasonably foreseeable circumstances. A detailed description of the MACT floor determination is in the memorandum "MACT Floor Analysis for New and Existing Sources in the Industrial, Commercial, and Institutional Boilers and Process Heaters Source Categories" in the docket.

<u>New Solid Fuel-fired Units</u>

<u>Large Units - Heat Inputs Greater than 10 MMBtu/hr</u>. The most effective control technology identified for removing PM from boilers in this subcategory is fabric filters. Therefore, the EPA considers a fabric filter to be the technology basis for the new source MACT floor for non-mercury metallic HAP emissions. The MACT floor emission level based on fabric filters is 0.04 lb PM/MMBtu. This PM emission level was selected from a subset of fabric filters contained in the database. This subset includes fabric filters assumed to be subject or achieving the NSPS for industrial boilers. The NSPS (40 CFR 60.40b), which represent best demonstrated technology for criteria pollutants, is based on the use of a fabric filter for PM and requires the use of a scrubber for sulfur dioxide. Therefore, fabric filters subjected to the NSPS are assumed to be better designed, and operated than those built prior to the NSPS.

We are also providing an alternative metals limit of 0.00007 lb metals/MMBtu which can be used to show compliance in cases where metal HAP emissions are low in proportion to PM emissions. The emissions database indicates that some biomass units have low metals content but high PM emissions. The emission level for metals was selected from metals test data associated with PM emission tests from fabric filters that met the MACT floor PM emission level. The most effective control technologies identified for removing inorganic HAP including acid gases, such as HCl, are wet scrubbers and packed bed scrubbers. Wet scrubbers is a generic term that is most often used to describe venturi scrubbers, but can include packed bed scrubbers, impingement scrubbers, etc. One percent of boilers and process heaters in this subcategory reported using a packed bed scrubber. Emission test data from other industries suggests that packed bed scrubbers achieve consistently lower emission levels than wet scrubbers. Therefore, the EPA considers a packed bed scrubber to be the technology basis for the new source MACT floor for acid gas control for boilers and process heaters in the solid fuel subcategory. The MACT floor emission level based on packed scrubbers is 0.016 lb HCl/MMBtu.

For mercury control, one technology, carbon injection, that has demonstrated mercury reductions in other source categories (i.e., municipal waste combustors), was identified as being used on one existing industrial boiler. However, test data on this carbon injection system indicated that this unit was not achieving mercury emissions reductions. Therefore, we did not consider carbon injection to be a MACT floor control technology for industrial, commercial, and institutional boilers and process heaters. Data from electric utility boilers indicate that fabric filters can achieve mercury emissions reductions. Therefore, the EPA considers a fabric filter to be the control technology basis for controlling mercury in this subcategory. The MACT floor emission level based on fabric filters is 0.0000026 lb mercury/MMBtu.

Similar control technology analysis was done for the boilers and process heaters in this subcategory for organic HAP. One control technique, controlling inlet temperature to the PM control device, that has demonstrated controlling downstream formation of dioxins in other source categories (e.g., municipal waste combustors) was analyzed for industrial boilers. Inlet and outlet dioxins test data were available on four boilers controlled with PM control devices. In all cases, no increase in dioxins emissions were indicated across the PM control device even at high inlet temperatures. However, we are requesting comment on controls that would achieve reductions of organic HAP, including any additional data that might be available. The EPA did find that CO monitoring can reduce organic HAP emissions, and has included it in the new source MACT floors as described under section III.F. of this preamble.

In light of this analysis, the EPA determined that the combination of a fabric filter, a packed bed scrubber, and CO monitoring forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

<u>Small Units - Heat Inputs Less than or Equal to 10 MMBtu/hr</u>. The most effective control technologies identified for removing non-mercury metallic HAP used by units in this subcategory are fabric filters. Therefore, the EPA considers fabric filters to be the technology basis for the new source MACT floor for non-mercury metallic HAP control in this subcategory. The most effective control technology identified for units in this subcategory for removing acid gases, such as HCl, are wet scrubbers. The most effective control technologies identified for removing mercury used by units in this subcategory are fabric filters.

The EPA identified no control technology being used in the existing population of boilers and process heaters that consistently achieved lower emission rates than uncontrolled levels, such that a best-controlled similar source for organic HAP could be identified. We concluded the MACT floor for new sources in this subcategory is no emissions reductions for organic HAP. Furthermore, CO monitoring is not required for small boilers and process heaters by any State rules.

Thus, the EPA determined that the combination of a fabric filter and a wet scrubber forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

The emissions test database did not contain test data for boilers and process heaters less than 10 MMBtu/hr heat input. In order to develop emission levels for this subcategory, we decided to use information from units in the large solid subcategory. We considered this to be an appropriate methodology because although the units in this subcategory are different enough to warrant their own subcategory (i.e., different designs and emissions), emissions of the specific HAP for which limits are being proposed (HCl, PM and metals) are expected to be related more to the type of fuel burned and the type of control used than to the unit design. Consequently, we determined that emissions information from units greater than 10 MMBtu/hr heat input could be used to establish the MACT floor levels for this subcategory for HCl, non-mercury metallic HAP (using PM as a surrogate), and mercury because the fuels and controls are similar.

The MACT floor emission level based on emissions data for fabric filters on solid fuel-fired boilers is 0.04 lb PM/MMBtu or 0.00007 lb selected non-mercury metals/MMBtu, and 0.0000026 mercury/MMBtu. The MACT floor emission level based on wet scrubbers is 0.032 lb HCl/MMBtu. .

<u>Limited Use Units - Capacity Utilizations Less than or Equal to 10 Percent</u>. The most effective control technologies identified for removing non-mercury metallic HAP and mercury used by

units in this subcategory are fabric filters. Therefore, the EPA considers fabric filters to be the technology basis for the new source MACT floor for non-mercury metallic HAP and mercury control in this subcategory. The most effective control technology identified for units in this subcategory for removing acid gases, such as hydrogen chloride, are wet scrubbers.

The EPA did find that monitoring CO is used by at least one unit and can reduce organic HAP emissions, and has included it in the new source MACT floor for this subcategory as described under section III.F of this preamble.

Therefore, based on this analysis, the EPA determined that the combination of a fabric filter, a wet scrubber, and CO monitoring forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

Consequently, we determined that emissions information from units greater than 10 MMBtu/hr heat input could be used to establish MACT floor levels for this subcategory because the fuels and controls are similar. The MACT floor emission level based on fabric filters is 0.04 lb PM/MMBtu or 0.00007 lb metals/MMBtu, and 0.0000026 mercury/MMBtu. The MACT floor emission level based on wet scrubbers is 0.032 lb HCl/MMBtu.

New Liquid Fuel-fired Units

Large Units - Heat Inputs Greater than 10 MMBtu/hr. The most effective control technologies identified for removing non-mercury metallic HAP and PM from units in this subcategory are fabric filters. Therefore, the EPA considers a fabric filter to be the technology basis for the new source MACT floor for non-mercury metallic HAP. A PM level is set as a surrogate for non-mercury metallic HAP control. The MACT floor emission level based on emission data for fabric filters on liquid fuel fired boilers is 0.068 lb PM/MMBtu. Unlike for solid fuel subcategories, we are not aware of any liquid fuels that are low in metals but would have high PM emissions. Therefore, we do not have an alternative metals standard for the liquid subcategories.

The most effective control technologies identified for removing inorganic HAP that are acid gases, such as HCl, are packed bed scrubbers. Therefore, the EPA considers a packed bed scrubber to be the technology basis for the new source MACT floor for acid gas control for boilers and process heaters in the liquid fuel subcategory. The MACT floor emission level based on packed scrubbers is 0.00045 lb HCl/MMBtu.

Similar control technology analyses were done for the boilers and process heaters in this subcategory for mercury and organic HAP.

Information in the emissions database or from other source categories does not show that control technologies, such as fabric filters or wet scrubbers, achieve reductions in mercury emissions from liquid fuel-fired industrial, commercial, and institutional boilers and process heaters. Therefore, EPA identified no control technology being used in the existing population of boilers and process heaters in these subcategories that consistently achieved lower emission rates than uncontrolled levels, such that a best-controlled similar source for organic HAP could be identified. However, we did find that monitoring CO is a good combustion practice that can reduce organic HAP emissions, and has included it in the new source MACT floor as described under section III.D of this preamble. We concluded the MACT floor for new sources in this subcategory is no emissions reductions for mercury.

In light of this analysis, the EPA determined that the combination of a fabric filter, a packed bed scrubber, and CO monitoring forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

Small Units - Heat Inputs Less than or Equal to 10 MMBtu/hr. The most effective control technologies identified for removing non-mercury metallic HAP used by units in this subcategory are fabric filters. Therefore, the EPA considers fabric filters to be the technology basis for the new source MACT floor for non-mercury metallic HAP control in this subcategory. The most effective control technology identified for units in this subcategory for removing acid gases, such as hydrogen chloride, are wet scrubbers.

Information in the emissions database or from other source categories does not show that other control technologies, such as fabric filters or wet scrubbers, achieve reductions in mercury emissions from liquid fuel-fired industrial, commercial, and institutional boilers and process heaters. Therefore, EPA could not identify a control technology being used in the existing population of boilers and process heaters that consistently achieved lower emission rates than uncontrolled levels, such that a best-controlled similar source for mercury or organic HAP could be identified. We concluded the MACT floor for new sources in this subcategory is no emissions reductions for mercury or organic HAP.

Thus, the EPA determined that the combination of a fabric filter and a wet scrubber forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

The emissions test database did not contain test data for boilers and process heaters less than 10 MMBtu/hr heat input. In order to develop emission levels for this subcategory, we decided to use information from units in the large liquid subcategory. We considered this to be an appropriate methodology because although the units in this subcategory are different enough to warrant their own subcategory (i.e., different designs and emissions), emissions of the specific types of HAP for which limits are being proposed (HCl and metals) are expected to be more related to the type of fuel burned and the type of control than to unit design. Consequently, we determined that emissions information from units greater than 10 MMBtu/hr heat input could be used to establish MACT floor levels for this subcategory because the fuels and controls are similar. The MACT floor emission level based on fabric filters is 0.068 lb PM/MMBtu. The MACT floor emission level based on wet scrubbers is 0.0009 lb HCl/MMBtu.

Limited Use Units - Capacity Utilizations Less than or Equal to 10 Percent. The most effective control technologies identified for removing non-mercury metallic HAP used by units in this subcategory are fabric filters. Therefore, the EPA considers fabric filters to be the technology basis for the new source MACT floor for non-mercury metallic HAP control in this subcategory. The most effective control technology identified for units in this subcategory for removing acid gases, such as hydrogen chloride, are wet scrubbers.

Information in the emissions database or from other source categories does not show that other control technologies, such as fabric filters or wet scrubbers, achieve reductions in mercury emissions from liquid fuel-fired industrial, commercial, and institutional boilers and process heaters. The EPA identified no control technology being used in the existing population of boilers and process heaters that consistently achieved lower emission rates than uncontrolled levels, such that a best-controlled similar source for mercury could be identified. We concluded the MACT floor for new sources in this subcategory is no emissions reductions for mercury.

We did find that monitoring CO can reduce organic HAP emissions and is used by at least one unit in this subcategory, and have included it in the new source MACT floor as described under section III.D of this preamble. Therefore, based on this analysis, the EPA determined that the combination of a fabric filter, a wet scrubber, and CO monitoring forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

The emissions test database did not contain test data for limited use liquid-fired boilers and process heaters. In order to develop emission levels for this subcategory, we decided to use information from units in the large liquid subcategory. Consequently, we determined that emissions information from units greater than 10 MMBtu/hr heat input could be used to establish MACT floor levels for this subcategory because the fuels and controls are similar. The MACT floor emission level based on fabric filters is 0.068 lb PM/MMBtu. The MACT floor emission level based on wet scrubbers is 0.0009 lb HCl/MMBtu.

Gaseous Fuel Subcategories

No existing units were using control technologies that achieve consistently lower emission rates than uncontrolled sources for any of the pollutant groups of interest, except organic HAP. At least one unit in the population database in the large and limited use gaseous fuel subcategories is required to monitor CO. Therefore, the MACT floor for gaseous fuel-fired units includes a CO monitoring requirement and emission limit, as described in section III.D of this preamble, but it does not include any emission limits for PM, metallic HAP, mercury, or inorganic HAP based on the utilization of add-on control technology.

How EPA Considered Beyond the Floor Options for New Units

The MACT floor level of control for new units is based on the emission control that is achieved in practice by the best controlled similar source within each of the subcategories. No technologies were identified that would achieve non-mercury metals reduction greater than the new source floors (i.e., fabric filters) for the liquid and solid subcategories or CO monitoring for the solid, liquid, and gaseous subcategories. For inorganic HAP control, we determined that packed bed scrubbers achieve higher emissions reductions than MACT floors consisting of a wet scrubber. Packed bed scrubbers are the technology basis of the MACT floor for the large unit subcategory, but wet scrubbers were the technology basis of the floors for the small unit and limited unit subcategories. Therefore, we examined the cost and emission reductions of applying a packed bed scrubber as a beyond the floor option for new solid and liquid units within the small and limited use subcategories. We determined that costs were excessive for the limited emission reduction that would be achieved. Non-air quality health, environmental impacts, and energy effects were not significant factors, because there would be little difference in the non-air quality health and environmental impacts between packed bed scrubbers and wet scrubbers. Therefore, the EPA did not select this beyond-the-floor option, and the proposed new source MACT level of control for PM, metallic HAP, and inorganic HAP (HCl) is the same as the MACT floor level of control for all of the subcategories.

In reviewing potential regulatory options beyond the new source MACT floor level of control, the EPA identified one existing solid fuel-fired industrial boiler that was using carbon injection technology for mercury control. However, emission data obtained from this unit indicated that it was not achieving mercury emission reductions from the uncontrolled levels. Moreover, we do not have information to otherwise show that carbon injection is effective for reducing mercury emissions from industrial, commercial, and institutional boilers and process heaters. Information in the emissions database or from other source categories does not show that other control technologies, such as fabric filters or wet scrubbers, achieve reductions in mercury emissions from liquid fuel-fired industrial, commercial, and institutional boilers and process heaters. Therefore, carbon injection, for solid fuel units, and other control techniques, for liquid fuel units, were not evaluated as regulatory options.

For the solid fuel and liquid fuel subcategories, fuel switching to natural gas is a potential regulatory option beyond the new source floor level of control that would reduce mercury and metallic HAP emissions. However, based on current trends within the industry, the EPA projects that the majority of new boilers and process heaters will be built to fire natural gas as opposed to solid and liquid fuels such that the overall emissions reductions associated with this option would be minimal. Furthermore, organic HAP may be increased by fuel switching. Limited emissions reductions in combination with the high cost of fuel switching and considerations about the availability and technical feasibility of fuel switching makes this an unreasonable regulatory option that was not considered further. Non-air quality health, environmental impacts, and energy effects were not significant factors. No beyond-the-floor options for gas-fired boilers were identified.

Based on the analysis discussed above, the EPA decided to not go beyond the MACT floor level of control for new sources for MACT in the rule.

1.2.4 Considerations of Possible Risk-Based Alternatives to Reduce Impacts to Sources

The Agency has made every effort in developing this rule to minimize the cost to the regulated community and allow maximum flexibility in compliance options consistent with our statutory obligations. However, we recognize that the rule may still require some facilities to take costly steps to further control emissions even though their emissions may not result in exposures which could pose an excess individual lifetime cancer risk greater than one in one million or which exceed thresholds determined to provide an ample margin of safety for protecting public health and the environment from the effects of hazardous air pollutants. We therefore solicited comment on whether there are further ways to structure the rule to focus on the facilities which pose significant risks and avoid the imposition of high costs on facilities that pose little risk to public health and the environment.

Representatives of the plywood and composite wood products industry provided EPA with descriptions of three mechanisms that they believed could be used to implement more cost-effective reductions in risk. The docket for today's rule contains "white papers" prepared by industry that outline their proposed approaches (see docket number A-98-44, Item # II-D-525). These approaches could be effective in focusing regulatory controls on facilities that pose significant risks and avoiding the imposition of high costs on facilities that pose little risk to public health or the environment, and we sought public comment on the utility of each of these approaches with respect to this rule.

One of the approaches, an applicability cutoff for threshold pollutants, would be implemented under the authority of CAA section 112(d)(4); the second approach, subcategorization and delisting, would be implemented under the authority of CAA sections 112(c)(1) and 112(c)(9); and, the third approach, would involve the use of a concentration-based applicability threshold. We sought comments on whether these approaches are legally justified and asked for information that could be used to support such approaches.

The approach the Agency has chosen to include in the final rule is the first approach - an applicability cutoff for threshold pollutants. The threshold pollutants for which an applicability cutoff is applied are hydrochloric acid (Hcl) and a series of eight metals known as the total selected metals (TSM).

1.2.4.1 Applicability Cutoffs for Threshold Pollutants Under Section 112(d)(4) of the CAA

This approach is an "applicability cutoff" for threshold pollutants that is based on EPA's authority under CAA section 112(d)(4). A "threshold pollutant" is one for which there is a concentration or dose below which adverse effects are not expected to occur over a lifetime of exposure. For such pollutants, section 112(d)(4) allows EPA to consider the threshold level, with an ample margin of safety, when establishing emissions standards. Specifically, section 112(d)(4) allows EPA to establish emission standards that are not based upon the maximum achievable control technology (MACT) specified under section 112(d)(2) for pollutants for which a health threshold has been established. Such standards may be less stringent than MACT. Historically, EPA has interpreted 112(d)(4) to allow us to avoid further regulation of categories of sources that emit only threshold pollutants, if those emissions result in ambient levels that do not exceed the threshold, with an ample margin of safety.[3]

In the past, EPA routinely treated carcinogens as non-threshold pollutants. The EPA recognizes that advances in risk assessment science and policy may affect the way EPA differentiates between threshold and non-threshold HAP. The EPA's draft Guidelines for Carcinogen Risk Assessment[4] suggest that carcinogens be assigned non-linear dose-response relationships where data warrant. Moreover, it is possible that dose-response curves for some pollutants may reach zero risk at a dose greater than zero, creating a threshold for carcinogenic effects. It is possible that future evaluations of the carcinogens emitted by this source category would determine that one or more of the carcinogens in the category is a threshold carcinogen or is a carcinogen that exhibits a non-linear dose-response relationship but does not have a threshold.

The dose-response assessments for formaldehyde and acetaldehyde are currently undergoing revision by the EPA. As part of this revision effort, EPA is evaluating formaldehyde and acetaldehyde as potential non-linear carcinogens. The revised dose-response assessments will be subject to review by the EPA Science Advisory Board, followed by full consensus review, before adoption into the EPA

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[1] See 63 FR 18754, 18765-66 (April 15, 1998) (Pulp and Paper Combustion Sources Proposed NESHAP)

[4] "Draft Revised Guidelines for Carcinogen Risk Assessment." NCEA-F-0644. USEPA, Risk Assessment Forum, July 1999. pp 3-9ff. http://www.epa.gov/ncea/raf/pdfs/cancer_gls.pdf

Integrated Risk Information System (IRIS). At this time, EPA estimates that the consensus review will be completed sometime in 2004. The revision of the dose-response assessments could affect the potency factors of these HAP, as well as their status as threshold or non-threshold pollutants. At this time, the outcome is not known. In addition to the current reassessment by EPA, there have been several reassessments of the toxicity of and carcinogenicity of formaldehyde in recent years, including work by the World Health Organization and the Canadian Ministry of Health.

1.2.4.2 Applicability Cutoffs for Hydrogen Chloride Controls Under Section 112(d)(4) of the CAA

HCl Compliance Alternative.

As an alternative to the requirement for each large solid fuel-fired boiler to demonstrate compliance with the HCl emission limit in the final rule, you may demonstrate compliance with a health-based facility-wide HCl equivalent allowable emission limit.

The procedures for demonstrating eligibility for the HCl compliance alternative (as outlined in appendix A of the final rule) are:

(1) You must include in your demonstration every emission point within the facility that emits a respiratory toxicant included on EPA's list of hazardous air pollutants.

(2) You must conduct HCl and chlorine emissions tests for every emission point covered under subpart DDDDD.

(3) You must obtain either through emission testing or through the development and documentation of best engineering estimates of maximum emissions of respiratory toxicants from all emission points at the facility not covered under subpart DDDDD of part 63 from which a respiratory toxicant might reasonably be emitted.

(4) You must determine the total maximum hourly mass HCl-equivalent emission rate for your facility by summing the maximum hourly toxicity-weighted emission rates of all appropriate respiratory toxicants (calculated using the maximum rated capacities of the units) for each of the units at your facility.

(5) Use the look-up table in the appendix A of subpart DDDDD to determine if your facility is in compliance with health-based HCl-equivalent emission limit.

(6) Select the maximum allowable HCl-equivalent emission rate from the look-up table in appendix A of subpart DDDDD of part 63 for your facility using the average stack height of your subpart DDDDD emission units as your stack height and the minimum distance between any respiratory toxicant emission point at the facility and the closest boundary of the nearest residential (or residentially zoned) area as your fenceline distance.

(7) Your facility is in compliance if your maximum HCl-equivalent emission rate does not exceed the value specified in the look-up table in appendix A of subpart DDDDD.

(8) As an alternative to using the look-up table, you may conduct a site-specific compliance demonstration (as outlined in appendix A of subpart DDDDD of part 63) which demonstrate that your facility cannot cause an individual chronic inhalation exposure from respiratory toxicants which can exceed a Hazard Index (HI) value of 1.0.

1.2.4.3 Applicability Cutoffs for Total Selected Metals Controls Under Section 112(d)(4) of the CAA

In lieu of complying with the emission standard for TSM in subpart DDDDD of part 63 based on the sum of emissions for the eight selected metals (arsenic, cadmium, chromium, mercury, manganese, nickel, lead, and), you may demonstrate eligibility for complying with the TSM standard based on excluding manganese emissions from the summation of TSM emissions for the affected source unit.

The procedures for demonstrating eligibility for the TSM compliance alternative (as outlined in appendix A of the subpart DDDDD) are:

(1) You must include in your demonstration every emission point within the facility that emits a CNS toxicant included on EPA's list of hazardous air pollutants.

(2) You must conduct manganese emissions tests for every emission point covered under subpart DDDDD that emits manganese.

(3) You must obtain either through emission testing or through the development and documentation of best engineering estimates of maximum emissions of CNS toxicants from all emission points at the facility not covered under subpart DDDDD from which a CNS toxicant might reasonably be emitted.

(4) You must determine the total maximum hourly manganese equivalent emission rate from your facility by summing the maximum hourly toxicity-weighted emission rates of all appropriate CNS toxicants (calculated using the maximum rated heat input capacities) for each of the units at your facility.

(5) Use the look-up table in appendix A of subpart DDDDD to determine if your facility is eligible for complying with the TSM limit based on the sum of emissions for seven metals (excluding manganese) for the affected source units.

(6) Select the maximum allowable manganese-equivalent emission rate from the look-up table in appendix A of subpart DDDDD for your facility using the average stack height of your subpart DDDDD emission units as your stack height and the minimum distance between any CNS toxicant emission point at the facility and the closest boundary of the nearest residential (or residentially zoned) area as your fenceline distance.

(7) Your facility is eligible if your maximum manganese-equivalent emission rate does not exceed the value specified in the look-up table in appendix A of subpart DDDDD.

(8) As an alternative to using look-up table to determine if your facility is eligible for the TSM compliance alternative, you may conduct a site-specific compliance demonstration (as outlined in appendix A of subpart DDDDD) which demonstrates that your facility cannot cause an individual chronic inhalation exposure from CNS toxicants which can exceed a HI value of 1.0.

If you elect to demonstrate eligibility for either of the health-based compliance alternatives, you must submit certified documentation supporting compliance with the procedures at least 1 year before the compliance date.

You must submit supporting documentation including documentation of all maximum capacities, existing control devices used to reduce emissions, stack parameters, and property boundary distances to each on-site source of HCl-equivalent and/or manganese-equivalent emissions.

You must keep records of the information used in developing the eligibility demonstration for your affected source.

To be eligible for either health-based compliance alternative, the parameters that defined your affected source as eligible for the health-based compliance alternatives (including, but not limited to, fuel type, type of control devices, process parameters documented as worst-case conditions during the emissions testing used for your eligibility demonstration) must be incorporated as Federally enforceable limits into your title V permit. If you do not meet these criteria, then your affected source is subject to the applicable emission limits, operating limits, and work practice standards in Subpart DDDDD.

If you intend to change key parameters (including distance of stack to the property boundary) that may result in lower allowable health-based emission limits, you must recalculate the limits under the provisions of this section, and submit documentation supporting the revised limits prior to initiating the change to the key parameter.

If you intend to install a new solid fuel-fired boiler or process heater or change any existing emissions controls that may result in increasing HCl-equivalent and/or manganese-equivalent emissions, you must recalculate the total maximum hourly HCl-equivalent and/or manganese-equivalent emission rate from your affected source, and submit certified documentation supporting continued eligibility under the revised information prior to initiating the new installation or change to the emissions controls.

Facilities that could not demonstrate that they are eligible to be included in the low-risk subcategory would be subject to MACT and possible future residual risk standards.

1.3 Other Federal Programs

There are a number of other federal programs that affect air pollutant emissions from these sources. The effects of similar federal programs are the following:

- The commercial and industrial solid waste incinerators (CISWI) standards (in 40 CFR 60 subparts CCCC and DDDD) regulate commercial and industrial non-hazardous solid waste incinerators. These standards are final as of Dec. 1, 2000. Sources subject to the CISWI rules are exempt from the requirements of this NESHAP.
- The utility HAPs study Report to Congress provides information used to determine whether fossil fuel fired utility boilers should be regulated in a future MACT standard. A fossil fuel-fired utility boiler is a fossil fuel-fired combustion unit with a heat input greater than 25 megawatts that serves a generator producing electricity for sale. Fossil fuel-fired utility boilers are exempt from this regulation. Non-fossil fuel-fired utility are, however, covered by this proposed standard.
- EPA's Office of Solid Waste is in the process of developing MACT standards for hazardous waste boilers. Boilers burning hazardous waste are not included in this regulation.
- Previously, EPA had codified new source performance standards (NSPS) for industrial boilers in 1986 (in 40 CFR 60 subparts Db and Dc) and revised portions of them in 1999. The NSPS regulates emissions of particulate matter (PM), sulfur dioxide (SO_2), and nitrogen oxides (NOx) from boilers constructed after June 19, 1984. Source subject to the NSPS are still subject to this NESHAP because the NESHAP regulates sources of hazardous air pollutants while the NSPS does not. However, in developing the NESHAP for industrial/commercial/institutional boilers and process heaters EPA minimized the monitoring, recordkeeping requirements, and testing requirements so as not to duplicate requirements.

1.4 Scope of the Analyses in the RIA

The MACT floor will affect approximately 5,600 existing and new units. EPA developed annual compliance costs for model units in each of 83 different model unit types. EPA then linked the annualized compliance costs from the model units to the estimated existing population of boilers and process heaters to obtain national impact estimates. In addition, the Agency projected entrance of new boilers and process heaters through the year 2005, and linked the annualized compliance costs to these projected new units.

The impacts of national compliance costs, including impacts to both existing and new units, on affected markets was then estimated using a computerized market model. EPA used changes in prices and quantities in energy markets and final product markets to estimate the firm-, industry-, market-, and societal-level impacts associated with the regulation. EPA then estimated changes in particulate matter (PM) concentrations associated with this regulation using an air quality model and then estimated the benefits associated with these changes in PM concentrations. To estimate the benefits, the Agency used an in-house model to calculate benefits and then monetize them for emission reductions in areas where the assignment of controls to affected sources is well-defined. The Agency then used a benefits transfer technique to apply the benefits estimates from reductions at sources with well-defined control assignments to calculate benefits in areas where the assignment of controls is not well-assigned. Finally, the Agency compared the benefits to the costs of the regulation.

Results of these analyses are presented for the final rule (MACT floor) and Option 1A. Results of the costs and some economic impact information are presented for Option 1B. There is insufficient information for estimating the economic impacts and small entity impacts associated with Option 1B, and the benefits estimate for this option is the same as that for Option 1A since there are no additional emissions reductions expected.

1.5 Organization of the Report

The remainder of this report is divided into ten chapters that describe the analysis methodologies and presents the analyses results:

- Chapter 2 provides background information on boiler and process heater technologies.
- Chapter 3 profiles existing boilers and process heaters by capacity, fuel type, and industry and presents projections of the future population of units in 2005.
- Chapter 4 profiles the industries with the largest number of affected facilities. Included are profiles of the lumber and wood products (SIC 24/NAICS 321), furniture and related product manufacturing (SIC 25/NAICS 337), paper and allied products (SIC 26/NAICS 322), and electrical services (SIC 49/NAICS 221) industries.
- Chapter 5 describes the methodology for assessing the economic impacts of the National Emission Standard for Hazardous Air Pollutants (NESHAP).
- Chapter 6 presents the results of the economic analysis, including market, industry, and social cost impacts.
- Chapter 7 provides the Agency's analysis of the regulation's impact on small entities.
- Chapter 8 presents the Agency's analysis of the changes in air quality associated with compliance with the regulation, and a description of the emissions inventories used in the air quality analysis.
- Chapter 9 presents the results of the qualitative benefits associated with implementation of this regulation.
- Chapter 10 presents the results of the quantitative and monetized benefits associated with implementation of this regulation and a comparison of the benefits to the costs of the rule.

In addition to these chapters, there are five appendicies as well. Appendix A provides information on the databases and equations used in the economic impact analysis, and Appendix B provides details on assumptions behind the operation of the economic model, along with results of sensitivity analyses. Appendix C provides some results from the air quality modeling conducted to determine reductions in concentrations of PM associated with the emissions reductions expected to take place. These results are for the above-the-floor option 1A only. Appendix D contains the results of sensitivity analyses and alternative calculations for our benefits estimates. Finally, Appendix E contains impact estimates associated with the health-based compliance alternatives for HCl and Mn sources.

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CHAPTER 2

BOILER AND PROCESS HEATER TECHNOLOGIES

The three categories of combustion devices affected under the regulations are industrial boilers, commercial and institutional (ICI) boilers, and process heaters. Although their primary function is to transfer heat generated from fuel combustion to materials used in the production process, the applications for boilers and process heaters are somewhat different. As a result, the primary industries using boilers may not be the same as those using process heaters. It is important to note that throughout this report the terms "boilers and process heaters," and "units" are synonymous with "ICI boilers and process heaters." Utility boilers primarily engaged in generating electricity are not covered by the NESHAP under analysis and are therefore excluded from this analysis.

Boilers are combustion devices used to produce steam or heat water. Steam is produced in boilers by heating water until it vaporizes. The steam is then channeled to applications within a facility or group of facilities via pipes. Steam is an important power and heating source for the U.S. economy. It is used in the preparation or manufacturing of many key products, such as paper, petroleum products, furniture, and chemicals. Steam is also used to heat buildings and to generate the majority of the electricity consumed in this country. There are literally thousands of boilers currently being used in the United States throughout a wide variety of industries.

Process heaters are primarily used as heat transfer units in which heat from fuel combustion is transferred to process fluids, although they may also be used to transfer heat to other nonfluid materials or to heat transfer materials for use in a process unit (not including generation of steam). Process heaters are generally used in heat transfer applications where boilers are inadequate. Often these are uses in which heat must be transferred at temperatures in excess of 90° to 204°C (200° to 400°F). Process heaters are used in the petroleum refining and petrochemical industries, with minor applications in the asphalt concrete, gypsum, iron and steel, and wood and forest products industries.

Since one of the main uses of boilers is to generate steam, some of the characteristics of steam are discussed in this chapter. This chapter also provides an overview of the various types of boiler and process heater characteristics and designs.

2.1 Characteristics of Steam

Steam, an odorless, invisible gas of vaporized water, may be interspersed with water droplets, which gives it a cloudy appearance. It is produced naturally when underground water is heated by volcanic processes and mechanically using boilers and other heating processes. When water is heated at atmospheric pressure, it remains in liquid form until its temperature exceeds 212°F, the boiling point of water. Additional heat does not raise the water's temperature but rather vaporizes the water, converting it into steam. However, if water is heated under pressure, such as in a boiler, the boiling point is higher than 212°F and more heat is required to generate steam. Once all the water has been vaporized into steam, the addition of heat causes the temperature and volume to increase. Steam's heating and work capabilities increase as it is produced under greater pressure coupled with higher temperatures. As steam escapes from the boiler, it can be directed through pipes to drive mechanical processes or to provide heat.

The steam used in most utility, industrial, and commercial applications is referred to as "clean steam." Clean steam encompasses steam purities ranging from pure, solid-free steam used in critical processes to filtered steam for less demanding applications. The various types of clean steam differ in steam purity and steam quality. Steam purity is a quantitative measure of contamination of steam caused by dissolved particles in the vapor or by tiny droplets of water that may remain in the steam. Steam quality is a measure of how much liquid water is mixed in with the dry steam (Fleming, 1992).

Firms select the levels of steam quality and steam purity for their applications based on the sensitivity of their equipment to impurities, water droplet size, and condensation as well as the requirements for their production process. Using clean steam minimizes the risk of product contamination and prolongs equipment life. Although there are infinite possible levels of water purity and quality, the term "clean steam" generally refers to three basic types of steam:

- filtered steam—produced by filtering plant steam using high-efficiency filters. Filtered steam is generally of high steam quality because most large water droplets and other contaminants will be filtered out.
- clean steam—steam that is frequently produced from deionized and distilled water. Deionized and distilled water is free of dissolved solids and ions, which may corrode pipework.
- pure steam—similar to clean steam except that it is always produced from deionized and distilled water.

Steam applications can be categorized by the amount of pressure required: hot water, low pressure, and high pressure. Low pressure is 0 to 15 pounds per square inch (psi) and high pressure steam is above 15 psi (*Plant Engineering*, 1991). Hot water systems, which generate little steam, are primarily used for comfort applications, such as hot water for a building. Low pressure applications include process heat and space heating. High pressure steam applications are more frequently used in industrial and utility applications. Some high pressure applications require that the steam be superheated, a process which ensures that the steam is free of water droplets, to avoid damaging sensitive equipment.

Electric cogenerators, such as large factories and processing facilities, use steam to drive turbines to generate electricity. A conventional steam electric power plant burns fossil fuels (coal, gas, or oil) in a boiler, releasing heat that boils water and converts it into high-pressure steam (see Figure 2-1). The steam enters a turbine where it expands and pushes against blades to turn the generator shaft and create electric current. In this way, the thermal energy of steam becomes mechanical energy, which is converted into electricity. Steam used to drive turbines generates most of the electric power in the United States (TXU, 2000).

Industrial operations use steam to perform work such as powering complex machinery operations, in the same way that electric utilities use steam to rotate turbines. Textile mills, pulp and paper mills, and other manufacturing outfits are examples of facilities that use steam to run machinery. Steam also provides heat and pressure for manufacturing processes. Industrial establishments use steam to provide heat for drying or to heat and separate materials. For example, the paper industry uses steam to heat rollers that dry paper during the final stages of the production process. Petroleum refineries and chemical producers use steam to heat petroleum, raw materials, and other inputs to separate inputs into their constituent components or to facilitate chemical interactions. In addition to these applications, steam is employed in many other industrial processes, including textile production, wood working, furniture making, metal working, food preparation, and the manufacture of chemicals. Substitutes for using steam as process heat include electrical heating equipment, infrared, and other radiant drying techniques. Electricity may be used to power machinery, as well. However, switching from steam-powered to electricity-powered machinery would require significant equipment retrofits or replacement.

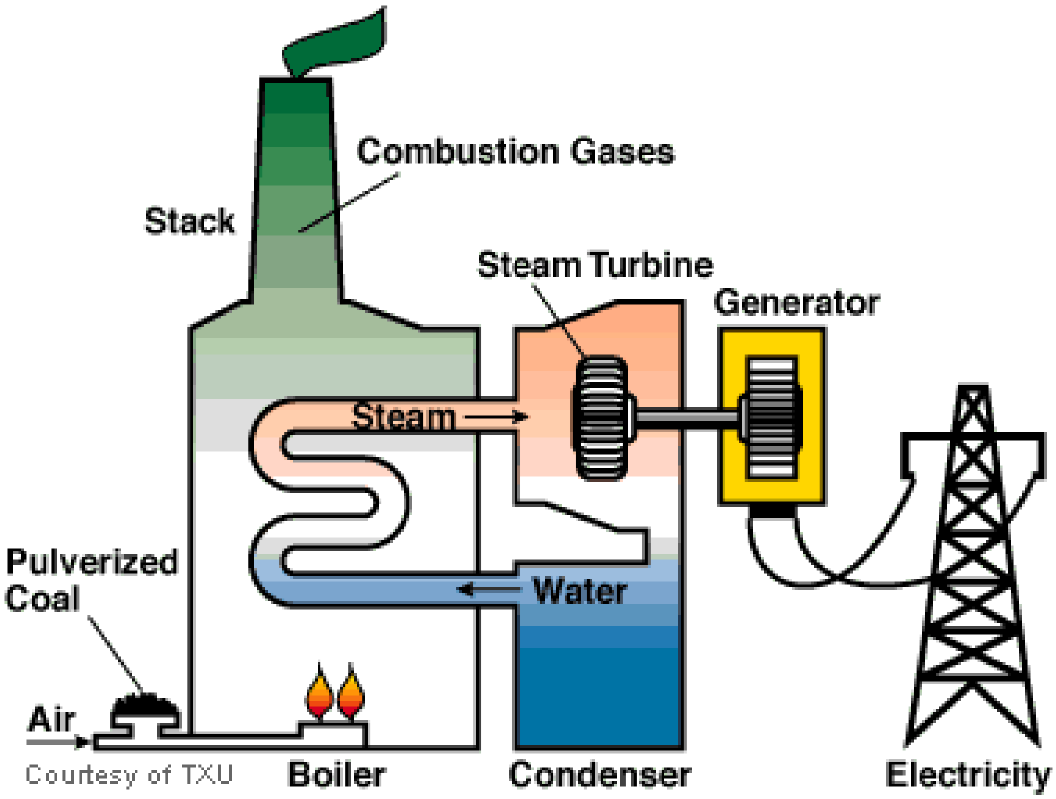

Figure 2-1. Generating Electricity: Steam Turbines

Source: Texas Utilities (TXU). 2000. "Generating Electricity: Steam Turbines." As obtained in September 2000. <http://www.txu.com/knowledge/energy_lib/generating01.html>.

Other steam applications include heating, sanitation, food processing and preparation, and cleaning. In addition to using boilers to heat water, factories, hospitals, government buildings, schools and other large buildings use boiler-generated steam to provide space heating. Substitutes for boilers in heating air and water include electrical water and space heaters; furnaces; and other heating, ventilation, and air conditioning equipment.

2.2 Fossil-Fuel Boiler Characterization

This section discusses the different classes of fossil-fuel boilers, the most common heat transfer configurations, and the major design types. The discussion indicates the type(s) of fuel that each design can use to operate.

2.2.1 Industrial, Commercial, and Institutional Boilers

Industrial, commercial, and institutional boilers are primarily used for process heating, electrical or mechanical power generation, and/or space heating. Industrial boilers are used in all major industrial sectors but primarily by the paper products, chemical, food, and petroleum industries.

It is estimated that the heat input capacity for these boilers is typically between 10 and 250 MMBtu/hr; however, larger industrial boilers do exist and are similar to utility boilers (EPA, 1997b). Commercial/institutional boilers are generally smaller than the industrial units, with heat input capacities generally below 10 MMBtu/hr. These units normally supply the steam and hot water for space heating in a wide range of locations, including wholesale and retail trade, office buildings, hotels, restaurants, hospitals, schools, museums, government buildings, and airports. Five hundred ninety-three of the 3,615 units potentially affected by the floor alternative for the proposed regulation are commercial/institutional units.

A boiler system includes the boiler itself, associated piping and valves, operation and safety controls, water treatment system, and peripheral equipment such as pollution control devices, economizers, or superheaters (*Plant Engineering*, 1991). Most boilers are made of steel, cast iron, or copper. The primary fuels used by boilers are coal, oil, and natural gas, but some use electricity, waste gases, or biomass.

Boilers may either be erected onsite (field-erected boilers) or assembled at a factory (packaged boilers). Packaged boilers are typically lower in initial cost and more simple to install. However, field-erected boilers may have lower operating costs, less maintenance, and greater flexibility because the furnace or convection pattern chosen to meet required steam pressure, capacity, and fuel specifications is tailored to the boiler's potential use (*Plant Engineering*, 1991). Applications requiring more than 100,000 pounds of steam per hour are usually equipped with a field-erected boiler.

2.2.2 Heat Transfer Configurations

The heat transfer configuration of a boiler refers to the method by which heat is transferred to the water. The four primary boiler configurations are watertube, firetube, cast iron, and tubeless. Most industrial users tend to rely on either watertube or firetube configurations.

In a watertube boiler, combustion heat is transferred to water flowing through tubes lining the furnace walls and boiler passes. The furnace watertubes absorb primarily radiative heat, while the watertubes in the boiler passes gain heat by convective heat transfer. These units have a wide range of heat input capacities (ICI units range from 0.4 to 1,500 MMBtu/hr) and can be either field erected or packaged.[1] Watertube boilers with heat input capacities greater than 200 MMBtu/hr are typically field erected.

Because firetube, cast iron, and tubeless heat transfer configurations typically have heat input capacities below 10 MMBtu/hr, they will not generally be covered by theNESHAP. Therefore, this profile focuses on those boiler types that use watertube heat transfer configurations.

2.2.3 Major Design Types

This section summarizes the five major design types for fossil fuel industrial boilers that will be covered by the NESHAP. It also discusses, where possible, the fuels used, capacity, and assembly method of each of these types of boilers.

2.2.3.1 Stoker-Fired Boilers (Coal)

These units use underfeed air to combust the coal char on a stationary grate, combined with one or more levels of overfire air introduced above the grate. There are three types of stoker units:

- spreader stokers,
- underfeed stokers, and
- overfeed stokers.

Stokers generally burn all types of coal, with the exception of overfeed stokers, which do not burn coking bituminous coals. Stokers can also burn other types of solid fuel, such as wood, wood waste, and bagasse. Spreader stokers are the most common of these boiler types and have heat input capacities that typically range from 5 to 550 MMBtu/hr. However, some of these boilers have capacities as high as 1,500 MMBtu/hr. Smaller stoker units (i.e., those with heat input capacities less than 100 MMBtu/hr) are generally packaged, while larger units are usually field erected.

2.2.3.2 Pulverized Coal Boilers (Coal)

Combustion in pulverized coal-fired units takes place almost entirely while the coal is suspended, unlike in stoker units in which the coal burns on a grate. Finely ground coal is typically mixed with primary combustion air and fed to the burner or burners, where it is ignited and mixed with secondary combustion air. Depending on the location of the burners and the direction of coal injection into the furnace, pulverized coal-fired boilers can be classified into three different firing types:

- single and opposed wall,
- tangential, and
- cyclone.

Of these types, wall and tangential configurations are the most common. These firing methods are described further in Sections 2.2.3.4 and 2.2.3.5.

2.2.3.3 Fluidized Bed Combustion (FBC) Boilers (Coal)

FBC is an integrated technology for reducing sulfur dioxide (SO_2) and NO_x emissions during the combustion of coal. In a typical FBC boiler, crushed coal and inert material (sand, silica, alumina, or ash) and/or a sorbent (limestone) are maintained in a highly turbulent suspended state by the upward flow of primary air from the windbox located directly below the combustion floor. This fluidized state provides a large amount of surface contact between the air and solid particles, which promotes uniform and efficient combustion at lower furnace temperatures than conventional coal-fired boilers. Once the hot gases leave the combustion chamber, they pass through the convective sections of the boiler, which are similar or identical to components used in conventional boilers.

For the FBCs currently in use in all sectors, coal is the primary fuel source, followed in descending order by biomass, coal waste, and municipal waste. The heat input capacities of all ICI FBC units generally range from 1.4 to 1,075 MMBtu/hr.

2.2.3.4 Tangentially Fired Boilers (Coal, Oil, Natural Gas)

The tangentially fired boiler is based on the concept of a single flame zone within the furnace. The fuel-air mixture projects from the four corners of the furnace along a line tangential to an imaginary cylinder located along the furnace centerline. As fuel and air are fed to the burners and the fuel is combusted, a rotating "fireball" is formed. Primarily because of their tangential firing pattern, which leads to larger flame volumes and flame interaction, uncontrolled tangentially fired boilers generally emit relatively lower NO_x than other uncontrolled boiler designs.

Utilities primarily use this type of boiler. Coal is the most common fuel used by these units. Tangentially fired boilers operated by utilities are typically larger than 400 MW, while industrial ones almost always have heat input capacities over 100 MMBtu/hr. In general, most units with heat input capacities over 100 MMBtu/hr are field erected.

2.2.3.5 Wall-fired Boilers (Coal, Oil, Natural Gas)

Wall-fired boilers are characterized by multiple individual burners located on a single wall or on opposing walls of the furnace. In contrast to tangentially fired boilers, each of the burners in a wall-fired boiler has a relatively distinct flame zone, and the burners in wall-fired boilers do not tilt. Superheated steam temperatures are instead controlled by excess air levels, heat input, flue gas recirculation, and/or steam attemperation (water spray). Depending on the design and location of the burners, wall-fired boilers are referred to as single wall or opposed wall.

Wall-fired boilers are used to burn coal, oil, or natural gas, and some designs feature multifuel capability. Almost all industrial wall-fired boilers have heat input capacities greater than 100 MMBtu/hr. Opposed-wall boilers in particular are usually much larger than 250 MMBtu/hr heat input capacity and are much more common in utility rather than in industrial operations. Because of their size, most wall-fired units are field erected. Field-erected watertube boilers strictly designed for oil firing are more compact than coal-fired boilers with the same heat input, because of the more rapid combustion characteristics of fuel oil. Field-erected watertube boilers fired by natural gas are even more compact because of the rapid combustion rate of the gaseous fuel, the low flame luminosity, and the ash-free content of natural gas.

2.3 Process Heater Characterization

Process heaters are heat transfer units in which heat from fuel combustion is transferred to materials used in a production process. The process fluid stream is heated primarily for one of two reasons: to raise the temperature for additional processing or to make chemical reactions occur. This section describes the different classes of process heaters and major design types.

2.3.1 Classes of Process Heaters

The universe of process heaters is divided into two categories:

- indirect-fired process heater—any process heater in which the combustion gases do not mix with or exhaust to the atmosphere from the same stack(s) or vent(s) with any gases emanating from the process or material being processed.

- direct-fired process heater—any process heater in which the combustion gases mix with and exhaust to the atmosphere from the same stack(s) or vent(s) with gases originating from the process or material being processed.

Indirect-fired units are used in situations where direct flame contact with the material being processed is undesirable because of problems with contamination and ignition of the process material. Direct-fired units are used where such problems are not an important factor. Emissions of indirect-fired units consist solely of the products of combustion (including those of incomplete combustion). On the other hand, direct-fired units will generate emissions consisting not only of the products of combustion, but also the process material(s). This means that the emissions from indirect-fired process heaters will be generic to the fuel in use and are common across industries while emissions from direct-fired process heaters are unique to a given process and may vary widely depending on the process material. Only indirect-fired process heaters are considered under this proposed regulation. Many direct-fired process heaters are being considered under separate MACT-development projects.

In addition to the distinction between direct- and indirect-fired heaters, process heaters may also be considered either heated feed or reaction feed. Heated feed process heaters are used to heat a process fluid stream before additional processing. These types of process heaters are used as preheaters for various operations in the petroleum refining industry such as distillation, catalytic cracking, hydroprocessing, and hydroconversion. In addition, heated feed process heaters are used widely in the chemical manufacturing industry as fired reactors (e.g., steam-hydrocarbon reformers and olefins pyrolysis furnaces), feed preheaters for nonfired reactors, reboilers for distillation operations, and heaters for heating transfer oils. Reaction feed process heaters are used to provide enough heat to cause chemical reactions to occur inside the tubes being heated. Many chemical reactions do not occur at room temperature and require the application of heat to the reactants to cause the reaction to take place. Applications include steam-hydrocarbon reformers used in ammonia and methanol manufacturing, pyrolysis furnaces used in ethylene manufacturing, and thermal cracking units used in refining operations.

2.3.2 Major Design Types

Process heaters may be designed and constructed in a number of ways, but most process heaters include burner(s), combustion chamber(s), and tubes that contain process fluids. Sections 2.3.2.1 through 2.3.2.4 describe combustion chambers setups, combustion air supply, tube configurations, and burners, respectively.

2.3.2.1 Combustion Chamber Set-Ups

Process heaters contain a radiant heat transfer area in the combustion chamber. This area heats the process fluid stream in the tubes by flame radiation. Equipment found in this area includes the burner(s) and the combustion chamber(s). Most heat transfer to the process fluid stream occurs here, but these tubes do not necessarily constitute a majority of the tubes in which the process fluid flows.

Most process heaters also use a convective heat transfer section to recover residual heat from the hot combustion gases by convective heat transfer to the process fluid stream. This section is located after the radiant heat transfer section and also contains tubes filled with process fluid. The first few rows of tubes in this section are called shield tubes and are subject to some radiant heat transfer. Typically, the process fluid flows through the convective section prior to entering the radiant section to preheat the process fluid stream. The temperature of the flue gas upon entering the convective section usually ranges from 800°C to 1,000°C (1,500°F to 2,000°F). Preheating in the convective section improves the efficiency of the process heater, particularly if the tube design includes fins or other extended surface areas. An extended tube surface area can improve efficiency by 10 percent. Extended tubes can reduce flue gas temperatures from 800°C to 1,000°C to (1,500°F to 2,000°F) to 120°C to 260°C (250°F to 500°F).

2.3.2.2 Combustion Air Supply

Air for combustion is supplied to the burners via either natural draft (ND) or mechanical draft (MD) systems. Natural draft heaters use ductwork systems to route air, usually at ambient conditions, to the burners. MD heaters use fans in the ductwork system to supply air, usually preheated, to the burners. The combustion air supply must have sufficient pressure to overcome the burner system pressure drops caused by ducting, burner registers, and dampers. The pressure inside the firebox is generally a slightly negative draft of approximately 49.8 to 125 Pascals (Pa) at the radiant-to-convective section transition point. The negative draft is achieved in ND systems via the stack effect and in MD systems via fans or blowers.

ND combustion air supply uses the stack effect to induce the flow of combustion air in the heater. The stack effect, or thermal buoyancy, is caused by the density difference between the hot flue gas in the stack and the significantly cooler ambient air surrounding the stack. Approximately 90 percent of all gas-fired heaters and 76 percent of all oil-fired heaters use ND combustion air supply (EPA, 1993).

There are three types of MD combustion air supply: forced draft, induced draft, and balanced draft. The draft types are named according to the position, relative to the combustion chamber, of the fans used to create the pressure difference in the process heater. All three types of MD heaters rely on the fans to supply combustion air and remove flue gas. In forced draft combustion air supply systems, the fan is located upstream from the combustion chamber, supplying combustion air to the burners. The air pressure supplied to the burners in a forced draft heater is typically in the range of 0.747 to 2.49 kilopascals (kPa). Though combustion air is supplied to the burners under positive pressure, the remainder of the process heater operates under negative pressure caused by the stack effect. In induced draft combustion air systems, the fan is located downstream of the combustion chamber, creating negative pressure inside the combustion chamber.

This negative pressure draws, or induces, combustion air into the burner registers. Balanced draft combustion air systems use fans placed both upstream and downstream (forced and induced draft) of the combustion chamber.

There are advantages and disadvantages for both ND and MD combustion air supply. One advantage to natural draft heaters is that they do not require the fans and equipment associated with MD combustion air supply. However, control over combustion air flow is not as precise in ND heaters as in MD heaters. MD heaters, unlike ND heaters, provide the option of using alternate sources of combustion oxygen, such as gas turbine exhaust. They also allow the use of combustion air preheat. Combustion air preheat has limited application in ND heaters due to the pressure drops associated with combustion air preheaters.

Combustion air preheaters are often used to increase the efficiency of MD process heaters. The maximum thermal efficiency obtainable with current air preheat equipment is 92 percent. Preheaters allow heat to be transferred to the combustion air from flue gas, steam, condensate, hydrocarbon, or other hot streams. The preheater increases the efficiency of the process heater because some of the thermal energy is reclaimed that would have been exhausted from the hot streams via cooling towers. If the thermal energy is from a hot stream other than the flue gas, the entire plant's efficiency is increased. The benefit of higher thermal efficiency is that less fuel is required to operate the heater.

2.3.2.3 Tube Configurations

The orientation of the tubes through which a process fluid stream flows is also taken into consideration when designing a process heater. The tubes in the convective section are oriented horizontally in most process heaters to allow cross-flow convection. However, the tubes in the radiant area may be oriented either horizontally or vertically. The orientation is chosen on a case-by-case basis according to the design specifications of the individual process heater. For example, the arbor, or wicket, type of heater is a specialty design to minimize the pressure drop across the tubes.

2.3.2.4 Burners

Many different types of burners are used in process heaters. Burner selection depends on several factors including process heat flux requirements, fuel type, and draft type. The burner chosen must provide a radiant heat distribution that is consistent with the configuration of the tubes carrying process fluid. Also, the number and location of the burner(s) depend on the process heater application.

Many burner flame shapes are possible, but the most common types are flat and conical. Flat flames are generally used in applications that require high temperatures such as ethylene pyrolysis furnaces, although some ethylene furnaces use conical flames to achieve uniform heat distribution. Long conical flames are used in cases where a uniform heat distribution is needed in the radiant section.

Fuel compatibility is also important in burner selection. Burners may be designed for combustion of oil, gas, or a gas/oil mixture. Gas-fired burners are simpler in operation and design than oil-fired burners and are classified as either premix or raw gas burners. In premix burners, 50 to 60 percent of the air necessary for combustion is mixed with the gas prior to combustion at the burner tip. This air is induced into the gas stream as the gas expands through orifices in the burner. The remainder of the air necessary for combustion is provided at the burner tip. Raw gas burners receive fuel gas without any premixed combustion air. Mixing occurs in the combustion zone at the burner tip.

Oil-fired burners are classified according to the method of fuel atomization used. Atomization is needed to increase the mixing of fuel and combustion air. Three types of fuel atomization commonly used are mechanical, air, and steam. Steam is the most widely used method because it is the most economical, provides the best flame control, and can handle the largest turndown ratios. Typical steam requirements are 0.07 to 0.16 kilogram (kg) steam/kg of oil.

Combination burners can burn 100 percent oil, 100 percent gas, or any combination of oil and gas. A burner with this capability generally has a single oil nozzle in the center of a group of gas nozzles. The air needed for combustion can be controlled separately in this type of burner. Another option is to base load the burners with one fuel and to add the other fuel to meet increases in load demand. Combination burners add flexibility to the process heater, especially when the composition of the fuel is variable.

The location and number of burners needed for a process heater are also determined on an individual basis. Burners can be located on the ceiling, walls, or floor of the combustion chamber. Floor- and wall-fired units are the most common burner types found in process heaters because they are both efficient and flexible. In particular, floor-mounted burners integrate well with the use of combustion air preheat, liquid fuels, and alternate sources of combustion oxygen such as turbine exhaust.

The number of burners in a heater can range from 1 to over 100. In the refinery industry, the average number of burners is estimated at 24 in ND heaters with an average design heat release of 69.4 million Btu per hour (MMBtu/hr). The average number of burners is estimated at 20 in MD heaters with ambient combustion air and an average design heat release of 103.6 MMBtu/hr. The average number of burners is estimated at 14 in MD heaters with combustion air preheat and an average design heat release of 135.4 MMBtu/hr. In general, the smaller the number of burners, the simpler the heater will be. However, multiple burners provide a more uniform temperature distribution.

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The floor-level MACT, which is the final industrial boilers and process heaters rule will affect existing and new ICI boilers and process heaters that have input capacity greater than 10 million Btus and are fueled by fossil and nonfossil fuel solids and liquids. In addition, two above-the-floor alternatives were investigated at proposal, Options 1A and 1B. Option 1A broadens the scope of affected units to include those fueled by residual fuel oil and units of covered fuel types with input capacities less than 10 million Btus. Option 1B further expands the affected population to include all distillate fuel oil and natural gas-fueled units. Although descriptive statistics on the Option 1B population are included in this section, this alternative was not analyzed for this RIA. More information on these options can be found in the preamble to the proposed regulation.

The economic impact estimates presented in Chapter 6 and the small entity screening analysis presented in Chapter 7 are based on the estimated stock of existing units and the projection of new units through the year 2005. They are also based on the compliance costs associated with the applying a regulatory alternative to these units. This chapter begins with a review of the industry distribution and technical characteristics of existing boilers and process heaters contained in the Agency's Inventory Database. It also presents projected growth estimates for boilers and process heaters through the year 2005, a description of how costs are estimated, and the national engineering cost estimates and cost-effectiveness (cost/ton) estimates by pollutant controlled.

3.1 Profile of Existing Boiler and Process Heaters Units

This section profiles existing boilers and process heaters, collectively referred to as "units," with respect to business applications, industry of parent company, and fuel use. The unit population database in combination with the model units that helped in preparing that database were used to determine which types of boilers, fuel, and control devices were in the existing unit population so that corresponding emission factors could be developed for all combinations. The development of the population database and the model units are discussed in the memoranda, "Development of the Population Database for the Industrial, Commercial, and Institutional Boiler and Process Heater National Emission Standard for Hazardous Air Pollutants (NESHAP)" and "Development of the Model Units for the Industrial, Commercial, and Institutional Boiler and Process Heater National Emission Standard for Hazardous Air Pollutants (NESHAP)." The units contained in the Inventory Database are based on information from the Aerometric Information Retrieval System (AIRS) and Ozone Transport Assessment Group (OTAG) databases, state and local permit records, and the combustion source Information Collection Request (ICR) conducted by the Agency in 1997. The list of units contained in the Inventory Database was reviewed and updated by industry and environmental stakeholders as part of the Industrial Combustion Coordinated Rulemaking (ICCR), chartered under the Federal Advisory Committee Act (FACA).

The entire Inventory Database contains more than 58,000 ICI boilers and process heaters; however, only about 4,000 are estimated to be affected by the floor alternative. Of these existing units, a little over half had sufficient information on operating parameters to be included in the floor-level EIA. The number of potentially affected units included in the profile for the floor alternative was 2,186. The number of units included in the profile was 3,580 for Option 1A and 22,117 for Option 1B.

3.1.1 Distribution of Existing Boilers and Facilities by Industry

Tables 3-1 through 3-3 present the number of existing boilers and process heaters and the number of facilities owning units by two-digit SIC code and three-digit NAICS code that may be affected by the floor or above-the-floor alternatives. For the floor alternative, the industries with the largest number of potentially affected units are the furniture, paper, lumber, and electrical services industries. These four industries alone account for nearly 60 percent of affected units. Almost all the process heaters are in the lumber industry. (Chapter 4 presents industry profiles for the lumber and wood products, electrical services, and paper industries, among others.) The remaining units are primarily distributed across the manufacturing sector and service industries. The distribution of units affected by the Option 1A alternative is similar to that for the floor alternative, although both the number of units and the number of facilities is greater for the Option 1A alternative. For Option 1B, the industries with the greatest number of units shifts to oil and gas exploration, chemical and transportation equipment manufacturing, and petroleum refining.

3.1.2 Technical Characteristics of Existing Boilers

Figure 3-1 characterizes the population of 2,186 (3,580; 22,117) units identified in the Inventory Database by capacity range, fuel type, and level of preexisting control for each alternative. Throughout most of this section, the values in the text are for the MACT floor alternative. Those for the above-the-floor alternatives follow in parentheses, first for Option 1A then for Option 1B.

Table 3-1. Units and Facilities Affected by the Floor Alternative by Industry[a]

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
01	111	Agriculture—Crops	3	0	3	3
02	112	Agriculture—Livestock	0	0	0	0
07	115	Agricultural Services	0	0	0	0
10	212	Metal Mining	9	0	9	4
12	212	Coal Mining	2	0	2	1
13	211	Oil and Gas Extraction	0	0	0	0
14	212	Mining/Quarrying—Nonmetallic Minerals	8	0	8	4
17	235	Construction—Special Trade Contractors	0	0	0	0
20	311	Food and Kindred Products	138	0	138	60
21	312	Tobacco Products	11	0	11	7
22	313	Textile Mill Products	135	0	135	71
23	315	Apparel and Other Products from Fabrics	2	0	2	2
24	321	Lumber and Wood Products	335	25	360	262
25	337	Furniture and Fixtures	234	0	234	154
26	322	Paper and Allied Products	321	0	321	194
27	511	Printing, Publishing, and Related Industries	0	0	0	0
28	325	Chemicals and Allied Products	171	3	174	70
29	324	Petroleum Refining and Related Industries	11	0	11	8
30	326	Rubber and Miscellaneous Plastics Products	17	0	17	13
31	316	Leather and Leather Products	1	0	1	1
32	327	Stone, Clay, Glass, and Concrete Products	9	0	9	7
33	331	Primary Metal Industries	41	0	41	16
34	332	Fabricated Metal Products	16	0	16	10
35	333	Industrial Machinery and Computer Equipment	23	0	23	12
36	335	Electronic and Electrical Equipment	5	0	5	5
37	336	Transportation Equipment	102	0	102	41
38	334	Scientific, Optical, and Photographic Equip.	8	0	8	4
39	339	Miscellaneous Manufacturing Industries	2	0	2	2
40	482	Railroad Transportation	4	0	4	1
42	484	Motor Freight and Warehousing	5	0	5	1
46	486	Pipelines, Except Natural Gas	0	0	0	0

(continued)

Table 3-1. Units and Facilities Affected by the Floor Alternative by Industry[a] (continued)

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
49	221	Electric, Gas, and Sanitary Services	318	0	318	160
50	421	Wholesale Trade—Durable Goods	3	0	3	2
51	422	Wholesale Trade—Nondurable Goods	2	0	2	1
55	441	Automotive Dealers and Gasoline Service Stations	0	0	0	0
58	722	Eating and Drinking Places	0	0	0	0
60	522	Depository Institutions	0	0	0	0
59	445–454	Miscellaneous Retail	0	0	0	0
70	721	Hotels and Other Lodging Places	1	0	1	1
72	812	Personal Services	0	0	0	0
76	811	Miscellaneous Repair Services	2	0	2	1
80	621	Health Services	37	0	37	18
81	541	Legal Services	0	0	0	0
82	611	Educational Services	105	0	105	45
83	624	Social Services	2	0	2	1
86	813	Membership Organizations	0	0	0	0
87	541	Engineering, Accounting, Research, Management and Related Services	2	0	2	2
89	711/514	Services, N.E.C.	2	0	2	1
91	921	Executive, Legislative, and General Administration	1	0	1	1
92	922	Justice, Public Order, and Safety	29	0	29	9
94	923	Administration of Human Resources	1	0	1	1
96	926	Administration of Economic Programs	4	0	4	3
97	928	National Security and International Affairs	29	0	29	11
NA		SIC Information Not Available	7	0	7	4
			2,158	28	2,186	1,214

[a] Based on the Inventory Database.

Table 3-2. Units and Facilities Affected by the Option 1A Alternative by Industry[a]

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
01	111	Agriculture—Crops	6	0	6	6
02	112	Agriculture—Livestock	0	0	0	0
07	115	Agricultural Services	0	0	0	0
10	212	Metal Mining	10	1	11	5
12	212	Coal Mining	2	0	2	1
13	211	Oil and Gas Extraction	8	10	18	4
14	212	Mining/Quarrying—Nonmetallic Minerals	10	0	10	5
17	235	Construction—Special Trade Contractors	2	0	2	1
20	311	Food and Kindred Products	163	0	163	72
21	312	Tobacco Products	22	0	22	11
22	313	Textile Mill Products	247	3	250	134
23	315	Apparel and Other Products from Fabrics	4	0	4	4
24	321	Lumber and Wood Products	434	28	462	337
25	337	Furniture and Fixtures	310	0	310	209
26	322	Paper and Allied Products	503	0	503	272
27	511	Printing, Publishing, and Related Industries	8	0	8	6
28	325	Chemicals and Allied Products	332	101	433	163
29	324	Petroleum Refining and Related Industries	54	108	162	50
30	326	Rubber and Miscellaneous Plastics Products	56	0	56	37
31	316	Leather and Leather Products	22	0	22	12
32	327	Stone, Clay, Glass, and Concrete Products	40	2	42	25
33	331	Primary Metal Industries	83	2	85	33
34	332	Fabricated Metal Products	44	0	44	28
35	333	Industrial Machinery and Computer Equipment	46	0	46	25
36	335	Electronic and Electrical Equipment	45	0	45	29
37	336	Transportation Equipment	158	0	158	61
38	334	Scientific, Optical, and Photographic Equip.	33	0	33	16
39	339	Miscellaneous Manufacturing Industries	14	0	14	10
40	482	Railroad Transportation	4	0	4	1
42	484	Motor Freight and Warehousing	5	2	7	3
46	486	Pipelines, Except Natural Gas	3	3	6	5

(continued)

Table 3-2. Units and Facilities Affected by the Option 1A Alternative by Industry[a] (continued)

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
49	221	Electric, Gas, and Sanitary Services	371	1	372	185
50	421	Wholesale Trade—Durable Goods	3	0	3	2
51	422	Wholesale Trade—Nondurable Goods	2	0	2	1
55	441	Automotive Dealers and Gasoline Service Stations	0	1	1	1
58	722	Eating and Drinking Places	0	0	0	0
60	522	Depository Institutions	0	0	0	0
59	445–454	Miscellaneous Retail	1	0	1	1
70	721	Hotels and Other Lodging Places	1	0	1	1
72	812	Personal Services	0	0	0	0
76	811	Miscellaneous Repair Services	2	0	2	1
80	621	Health Services	40	0	40	19
81	541	Legal Services	0	0	0	0
82	611	Educational Services	114	0	114	50
83	624	Social Services	3	0	3	2
86	813	Membership Organizations	0	0	0	0
87	541	Engineering, Accounting, Research, Management and Related Services	6	0	6	5
89	711/514	Services, N.E.C.	2	0	2	1
91	921	Executive, Legislative, and General Administration	2	0	2	2
92	922	Justice, Public Order, and Safety	33	0	33	10
94	923	Administration of Human Resources	1	0	1	1
96	926	Administration of Economic Programs	4	0	4	3
97	928	National Security and International Affairs	41	0	41	13
NA		SIC Information Not Available	24	0	24	18
			3,318	262	3,580	1,881

[a] Based on the Inventory Database.

Table 3-3. Units and Facilities Affected by the Option 1B Alternative by Industry[a]

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
01	111	Agriculture—Crops	7	0	7	6
02	112	Agriculture—Livestock	6	0	6	1
07	115	Agricultural Services	3	0	3	1
10	212	Metal Mining	55	6	61	20
12	212	Coal Mining	20	6	26	5
13	211	Oil and Gas Extraction	497	657	1,154	371
14	212	Mining/Quarrying—Nonmetallic Minerals	48	1	49	19
17	235	Construction—Special Trade Contractors	2	0	2	1
20	311	Food and Kindred Products	441	3	444	145
21	312	Tobacco Products	69	0	69	30
22	313	Textile Mill Products	755	6	761	347
23	315	Apparel and Other Products from Fabrics	4	0	4	4
24	321	Lumber and Wood Products	561	40	601	412
25	337	Furniture and Fixtures	499	10	509	297
26	322	Paper and Allied Products	981	0	981	493
27	511	Printing, Publishing, and Related Industries	333	3	336	134
28	325	Chemicals and Allied Products	2,265	415	2,680	913
29	324	Petroleum Refining and Related Industries	322	729	1,051	184
30	326	Rubber and Miscellaneous Plastics Products	508	36	544	268
31	316	Leather and Leather Products	91	2	93	44
32	327	Stone, Clay, Glass, and Concrete Products	423	13	436	184
33	331	Primary Metal Industries	754	197	951	314
34	332	Fabricated Metal Products	771	102	873	388
35	333	Industrial Machinery and Computer Equipment	402	19	421	191
36	335	Electronic and Electrical Equipment	430	13	443	203
37	336	Transportation Equipment	803	207	1,010	291
38	334	Scientific, Optical, and Photographic Equip.	180	2	182	71
39	339	Miscellaneous Manufacturing Industries	123	36	159	65
40	482	Railroad Transportation	4	0	4	1
42	484	Motor Freight and Warehousing	5	2	7	3
46	486	Pipelines, Except Natural Gas	8	3	11	7

(continued)

Table 3-3. Units and Facilities Affected by the Option 1B Alternative by Industry[a] (continued)

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
49	221	Electric, Gas, and Sanitary Services	1,227	140	1,367	615
50	421	Wholesale Trade—Durable Goods	4	0	4	2
51	422	Wholesale Trade—Nondurable Goods	2	0	2	1
55	441	Automotive Dealers and Gasoline Service Stations	0	2	2	2
58	722	Eating and Drinking Places	0	3	3	1
60	522	Depository Institutions	3	0	3	1
59	445–454	Miscellaneous Retail	1	0	1	1
70	721	Hotels and Other Lodging Places	3	0	3	2
72	812	Personal Services	2	0	2	1
76	811	Miscellaneous Repair Services	58	0	58	28
80	621	Health Services	27	0	27	25
81	541	Legal Services	2	0	2	0
82	611	Educational Services	144	0	144	57
83	624	Social Services	4	0	4	2
86	813	Membership Organizations	1	0	1	1
87	541	Engineering, Accounting, Research, Management and Related Services	6	0	6	5
89	711/514	Services, N.E.C.	2	0	2	1
91	921	Executive, Legislative, and General Administration	7	0	7	5
92	922	Justice, Public Order, and Safety	36	0	36	10
94	923	Administration of Human Resources	2	0	2	2
96	926	Administration of Economic Programs	11	0	11	5
97	928	National Security and International Affairs	51	3	54	15
NA		SIC Information Not Available	6,163	335	6,498	2,378
			19,126	2,991	22,117	8,573

[a] Based on the Inventory Database.

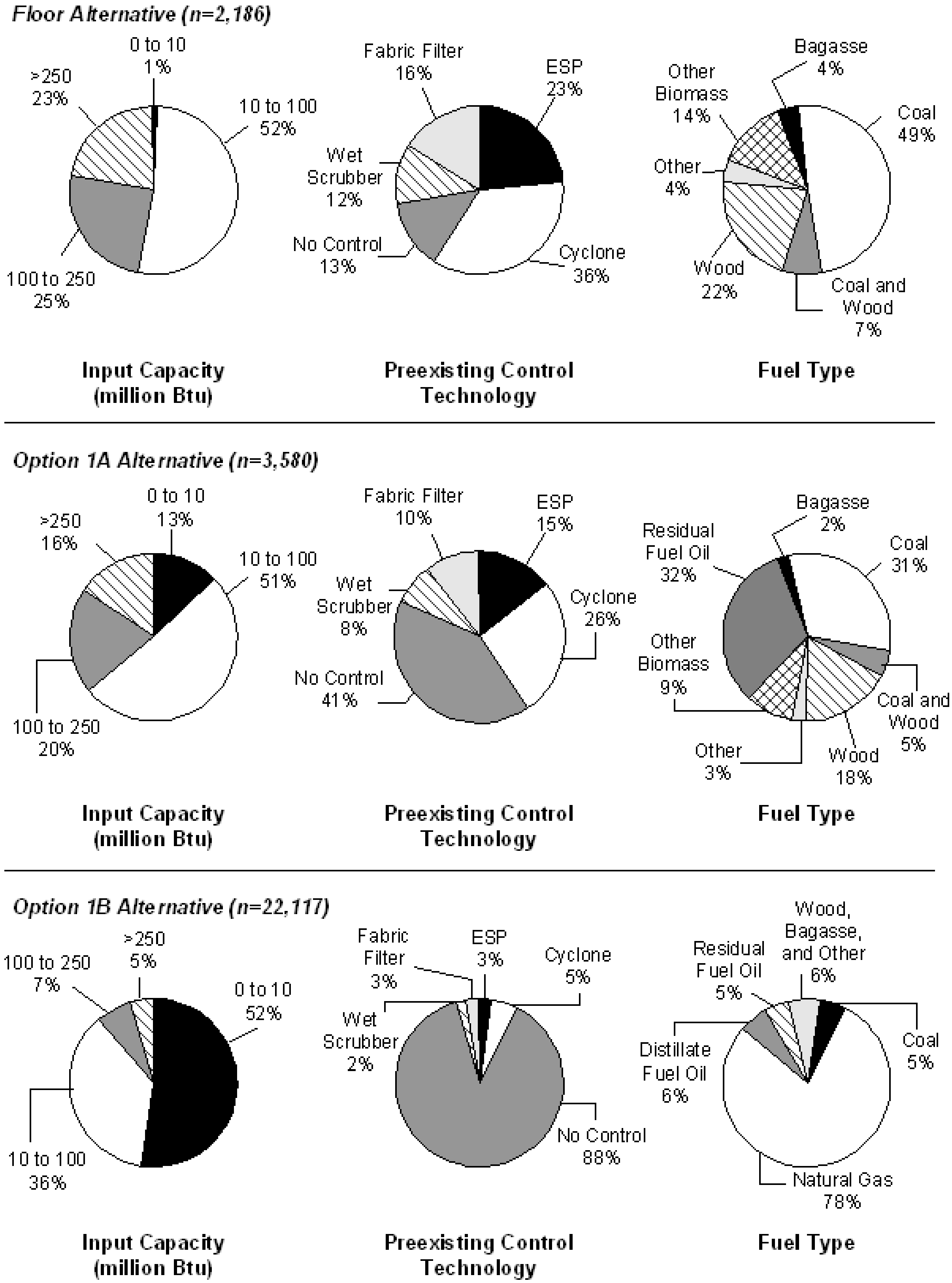


Figure 3-1. Characteristics of Units Affected by Alternatives

3.1.2.1 Floor Alternative

- Capacity Range: Unit input capacities in the population are expressed in four ranges: 0–10, 10–100, 100–250, and >250 MMBtu/hr. Fifty-two percent of the units affected for this alternative have capacities between 10 and 100 MMBtu/hr. The two largest capacity ranges each contain approximately one quarter of the population. Only 1 percent of units have input capacities less than 10 MMBtu/hr.

- Fuel Type: About half of these units consume coal as their primary fuel (1,074 units). After coal, the next most common fuel type is wood (479 units).

- Control Level: Eighty-three percent of units have some type of control device already installed; 289 do not. Typical control devices include fabric filters, wet scrubbers, and electrostatic precipitators.

3.1.2.2 Option 1A Alternative

- Capacity Range: About half of the 3,580 units affected by this alternative have input capacities between 10 and 100 MMBtu/hr. Twenty percent have capacities between 100 and 250, 16 percent have capacities greater than 250, and 13 percent have capacities less than 10 MMBtu/hr.

- Fuel Type: Coal and residual fuel oil are the primary fuel types each accounting for slightly less than one-third of the units. The remaining third primarily consists of units that consume wood or some other type of biomass fuel.

- Control Level: Forty-one percent have no existing pollution control equipment installed. Typical control devices include fabric filters, wet scrubbers, and electrostatic precipitators.

3.1.2.3 Option 1B Alternative

- Capacity Range: More than half of the 22,117 units affected by the Option 1B alternative have input capacities less than 10 MMBtu/hr. Thirty-six percent have input capacities between 10 and 100 MMBtu/hr. The remaining 12 percent have input capacities in excess of 100 MMBtu/hr.

- Fuel Type: This alternative includes those units affected under Option 1A, as well as a large number of natural gas units that were not affected under Option 1A. The vast majority of the 78 percent of the total number of potentially affected units are fueled by natural gas.

- Control Level: Eighty-eight percent of the affected units have no preexisting control equipment.

3.2 Methodology for Estimating Cost Impacts

The predominant type of control measure that is considered in the analysis of emission reductions needed for sources to achieve the MACT floor, which is the proposed alternative, as well as other alternatives, are add-on control technologies. Add-on control techniques are those technologies that are applied to the vent gas stream of the boiler or process heater to reduce emissions. The boiler and process heaters population database includes information on all control techniques that are applied to industrial, commercial, institutional boilers and process heaters. Generally, they can be grouped into PM control or acid gas control. The most common technologies, and the ones analyzed for the impacts analysis, include fabric filters, ESP's, packed scrubbers, venturi scrubbers, and spray dryers. In addition, when add-on technologies are used, the cost of ductwork and associated equipment also needed to be considered.

Components of capital cost include:

- purchased equipment cost of the primary device and auxiliary equipment,
- instrumentation,
- sales tax and freight, and
- installation costs. Installation costs include foundations and support, handling and erection, electrical, piping, insulation, and painting, engineering, construction and field expenses, contractor fees, start-up, performance tests, and contingencies.

Components of annual cost include:

- raw materials,
- utilities (electricity, fuel, steam, air, water),
- waste treatment and disposal,
- labor (operating, supervisory, maintenance),
- maintenance materials,
- replacement parts,
- overhead,
- property taxes,
- insurance,
- administration charges, and
- capital recovery costs.

For this analysis, costs were estimated in 1999 dollars. Capital recovery was calculated assuming 7 percent interest rate over the life of the equipment. The use of this interest rate is based on Office of Management and Budget (OMB) guidance (Circular A-94, October 29, 1992).

The algorithms used to estimate these costs were obtained from previous EPA studies. These cost algorithms are included as appendicies to the cost methodology memorandum in the public docket. Inputs for the algorithms used in the impacts analysis are also presented in this memorandum.

Fabric filter

The algorithms used to estimate capital and annual costs of fabric filters were obtained from EPA's EPA Air Pollution Control Cost Manual. Algorithms were provided for 4 types of fabric filters: shaker, reversed air, pulse-jet modular, and pulse-jet common. The cost algorithms for estimating capital costs reduced to basic equations for each are provided in Appendix A-1 of the cost methodology memorandum (henceforth called the "cost memo"). Capital costs are based on the gross cloth area of the fabric filter, which is a function of the gas inlet flow rate. Algorithms for calculating annual costs are provided in Appendix A-2 of the cost memo. Annual costs include dust disposal, electricity, maintenance, labor, bag replacement, maintenance labor, compressed air, overhead, administrative, property taxes, and insurance. Capital recovery is annualized over 20 years at 7 percent interest. Appendix A-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Electrostatic Precipitator

The algorithms used to estimate capital and annual costs of ESPs were obtained from EPA's Air Pollution Control Cost Manual. Capital costs are based on the total collection plate area, which is calculated from the gas inlet flow rate and the required removal efficiency. The cost algorithms for estimating capital costs of ESPs reduced to basic equations are provided in Appendix B-1 of the cost memo. Algorithms for calculating annual costs are provided in Appendix B-2 of the cost memo. Annual costs include dust disposal, electricity, maintenance, labor, maintenance labor, overhead, administrative, property taxes, and insurance. Capital recovery is annualized at 7 percent interest. Appendix B-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Venturi Scrubber

The algorithms used to estimate capital and annual costs of venturi scrubbers were obtained from EPA cost algorithms on EPA's website(http://www.epa.gov/ttn/catc/products.html#cccinfo.) Capital costs include not only the cost of the venturi scrubber but also a pump to provide motive force for the solvent. Capital costs are based on the gas flow rate and saturation temperature of the gas-solvent. The cost algorithms for estimating capital costs of each piece of equipment were reduced to basic equations in Appendix C-1 of the cost memo. The cost algorithms for estimating annual costs were reduced to basic equations in Appendix C-2 of the same memorandum. Annual costs include wastewater disposal, solvent, electricity, maintenance, labor, maintenance labor overhead, administrative, property taxes, and insurance. Capital recovery is an annualized cost estimated using a 7 percent interest rate. Appendix C-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Packed Bed Scrubber

The algorithms used to estimate capital and annual costs of packed bed scrubbers were obtained from EPA's Air Pollution Control Cost Manual. The capital costs are comprised of the scrubber tower, packing, pumps, and fans. Capital costs are based primarily on gas flow rate and removal efficiency. The cost algorithms for estimating capital costs of packed scrubber equipment reduced to their basic equations for each are provided in Appendix D-1 of the cost memo. The cost algorithms for estimating annual costs of packed scrubbers are provided in Appendix D-2 of the cost memo. Annual costs include caustic, wastewater disposal, water, electricity, maintenance, labor, overhead, administrative, property taxes, and insurance. Capital recovery is an annualized cost estimated using a 7 percent interest rate. Appendix D-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Spray Dryer

The algorithms used to estimate capital and annual costs of spray dryers were obtained from previous EPA studies. Capital costs include the cost of the spray dryer and pumps. Capital costs are based on the gas flow rate. The cost algorithms for estimating capital costs of spray dryer equipment reduced to basic equations are provided in Appendix E-1 of the cost memo. The cost algorithms for estimating annual costs for spray dryers are provided in Appendix E-2 of the cost memo. Annual costs include lime, water, electricity, maintenance, labor, maintenance labor, overhead, administrative, property taxes, and insurance. Capital recovery is an annualized cost estimated using a 7 percent interest rate. Appendix E-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Ductwork

The algorithms used to estimate capital and annual costs of ductwork were obtained from EPA's Air Pollution Control Cost Manual. Capital costs include 500 feet of ductwork, elbows, and fans. The 500 feet of ductwork was based on engineering judgement and previous experience on the distance between emission points and control devices in chemical facilities and the availability of space for retrofitting controls. Costs are based on ductwork diameter, which is calculated from the gas flow rate. The cost algorithms for estimating capital costs and annual costs reduced to basic equations are provided in Appendix F-1 of the cost memo. Annual costs include electricity, maintenance, maintenance labor, overhead, administrative, property taxes, and insurance. Capital recovery is an annualized cost estimated using a 7 percent interest rate. Required inputs to the ductwork algorithms are provided in the input tables provided in Appendices A-3, B-3, C-3, D-3, and E-3 of the cost memo.

Good Combustion Practices

Few sources in the population database specifically reported using good combustion practices. Boilers and process heaters within each subcategory might use any of a wide variety of different work practices, depending on the characteristics of the individual unit.

Consequently, any uniform requirements or set of work practices that would meaningfully reflect the use of good combustion practices, or that could be meaningfully implemented across any subcategory of boilers and process heaters could not be identified.

Additionally, few of the GCP's have been documented to reduce organic HAP emissions, and they could not be considered in the MACT analysis. One GCP that may effect organic HAP emissions is maintaining CO emission levels. CO is generally an indicator of incomplete combustion because CO will burn to carbon dioxide if adequate oxygen is available. Controlling CO emissions is a mechanism for ensuring combustion efficiency, and therefore may be viewed as a kind of GCP.

Capital and annual costs for CO monitoring is presented in Appendix G of the cost memo. The costing information was obtained from a previous EPA study. Capital costs are comprised of the initial cost of the equipment. Annual costs include operating and maintenance costs, annual and quarterly checks, recordkeeping and reporting, taxes, insurance, and administrative costs. Annualized costs such as capital recovery costs are calculated assuming an equipment life of 20 years and an interest rate of 7 percent.

Testing and Monitoring Costs

The rule includes emission limits for HCl, PM, metallic HAP, and mercury. Additionally, as mentioned in Chapter 1 of this RIA and the preamble, the rule allows sources to meet requirements by monitoring fuel content instead of emissions. Consequently, testing and monitoring costs of meeting the standards were incorporated into the cost estimates. Capital costs for testing include initial stack tests for PM, HCl, and metals for fossil fuels, and materials and fuel analysis for biomass. Capital cost components include operation and maintenance costs and capital recovery assuming the initial capital investment is annualized over a 5 year period at 7 percent interest. Monitoring costs are included for opacity monitoring, HCl monitoring, and scrubber parametric monitoring.[5] Monitoring costs include the capital cost of monitoring equipment, and the annual costs of capital recovery assuming the initial capital investment is annualized over a 20 year period at 7 percent interest. Annual monitoring costs also include operation and maintenance as well as other additional costs. The testing and monitoring costs are shown in Table 3-4. Appendix G of the cost memo includes further details on these costs. Information used to estimate testing and monitoring costs were obtained from previous EPA studies.

Table 3-4. Testing and Monitoring Costs for Units Covered by the Proposed Rule

[5] The monitoring costs reported for existing units are not the cost of continuous emission monitors (CEM), but the costs associated with monitoring the process parameters of the control device. Installation of these process monitors are integral to the control device and would be installed with or without the monitoring requirements of the MACT. Therefore, even though we present these monitoring costs separately, they are included in the overall reported control costs and should not be considered as an additional cost for emission monitoring.

Material or Fuel	No. of Industrial Boilers	No. of Process Heaters	Total Capital Investment of Testing and Monitoring ($)	Total Annual Costs of Testing ($)	Total Annual Costs of Monitoring ($)	Annual Capital Recovery - Testing and Monitoring (1999$)	Total Annual Costs of Testing and Monitoring (1999$)
Regular Use Units							
Coal	2,328	0	151,169,238	63,608,655	59,828,340	8,265,169	123,436,995
Coal/Wood/NFF[a] Liquid/NFF Solid	169	0	8,847,579	2,444,456	1,302,784	280,698	3,747,240
Gas	30,473	13,481	0	0	0	0	0
Gas/Wood/Other Biomass/Liquid FF	201	0	9,831,749	2,909,994	2,327,840	447,120	5,237,834
Distillate Liquid FF	2,921	353	0	0	0	0	0
NFF Liquid/NFF Solid/Gas	115	11	7,452,131	3,074,918	2,930,348	404,077	6,005,266
Wood	663	42	26,446,200	5,268,614	6,392,240	1,411,706	11,660,854
Wood/Other Biomass/NFF Liquid/NFF Solid	147	0	8,180,852	3,003,146	2,001,492	299,112	5,004,638
Residual Liquid FF	2,036	674	0	0	0	0	0
Bagasse/Other	132	0	5,821,106	490,000	2,891,728	412,546	3,381,728
Total for Regular Use Units	39,185	14,561	217,748,855	80,799,783	77,674,772	11,520,428	158,114,555
Limited Use Units							
Coal	198	0	6,427,715	1,584,000	1,716,416	457,169	3,330,416
Coal/Wood/NFF Liquid/NFF Solid	4	0	119,600	32,000	29,772	8,268	61,772
Gas	2,314	624	0	0	0	0	0
Gas/Wood/Other Biomass/Liquid FF	8	0	290,366	64,000	105,020	21,366	169,020
Distillate Liquid FF	672	31	0	0	0	0	0
NFF Liquid/NFF Solid/Gas	4	1	156,800	40,000	39,696	11,024	79,696
Wood	28	0	1,074,549	224,000	331,200	80,279	555,200
Wood/Other Biomass/NFF Liquid/NFF Solid	6	0	194,000	48,000	49,620	13,780	97,620
Residual Liquid FF	533	31	0	0	0	0	0

Material or Fuel	No. of Industrial Boilers	No. of Process Heaters	Total Capital Investment of Testing and Monitoring ($)	Total Annual Costs of Testing ($)	Total Annual Costs of Monitoring ($)	Annual Capital Recovery - Testing and Monitoring (1999$)	Total Annual Costs of Testing and Monitoring (1999$)
Total for Limited Use Units	3,767	687	8,263,030	1,992,000	2,271,724	591,886	4,263,724
Grand Total	42,952	15,248	226,011,885	82,791,783	79,946,496	12,112,314	162,738,279

[a] NFF = costs for units that are not fossil fueled; FF = units that are fossil fueled.

Costs to Control Non-Air Effects Related to Rule Implementation

The EPA estimated the additional water usage that would result from the MACT floor level of control to be 110 million gallons per year for existing sources and 0.6 million gallons per year for new sources. In addition to the increased water usage, an additional 3.7 million gallons per year of wastewater would be produced for existing sources and 0.6 million gallons per year for new sources. The EPA estimated the additional solid waste that would result from the MACT floor level of control to be 102,000 tons per year for existing sources and 1 ton per year for new sources. The costs ($900,000) of handling the additional solid waste generated from applying MACT floor technology are accounted for in the control cost estimates for ESP and fabric filter applications. The costs ($20,000) of treating wastewater from venturi and packed bed scrubber are also accounted for in the control cost estimates.

Cost Uncertainties

The primary limitation to the cost estimates developed for the proposed rule is that costs were calculated for model units rather than each individual boiler or process heater. Consequently, the costs do not characterize any "real" unit. This was done for practical reasons. Because there are over 60,000 units in the U.S., it would not be possible to gather unit-specific information for each unit necessary for estimating costs, such as flue gas temperatures and flow rates. Additionally, emission information was only available for less than 1 percent of the units. In order to estimate costs and emission reductions of the proposed rule, model units were developed to represent the population of boilers and process heaters in the U.S. While sufficient information was not available for characterizing each unit, sufficient emissions and process information were available to develop model units. Each unit in the U.S. was then assigned to a model based on their size and fuel burned. It also should be noted that the costing methodology is the cost algorithms for the control devices provide a cost range of +/- 30 percent. This aspect of the costing methodology reflects the degree of variability typically found in study-level cost estimates. This is also the degree of variability found in the cost methodology employed in the EPA Air Pollution Control Cost Manual, which is an important reference for the cost estimates supplied in the RIA. Cost information available to owners and operators of boilers and process heaters will be more specific and accurate. Consequently, the cost estimates may overestimate or underestimate costs.

3.3 Projection of New Boilers and Process Heaters

Energy Information Administration fuel consumption forecasts were used in conjunction with existing model boiler population data to project the number and type of new boilers to be installed by 2005. EPA used the following steps to calculate new boiler population estimates:

1. *Calculate the percentage change in industrial fuel consumption*. Energy Information Administration data were used to obtain industrial and commercial fuel use projections. The percentage change in consumption (1998 to 2005) in the industrial and commercial sectors was calculated for the following fuel categories using 1998 as the base year (the same year that the model boiler algorithms are based on): steam coal (2.6%), natural gas (6.3%), residual fuel oil (-7.4%), distillate fuel oil (12.0%), and biomass (11.5%). It should be noted

that 1998 was a year of below average energy prices, and that current and potential future energy prices are higher than the historical average. If real fuel prices increase faster than the EIA's projections, then conservation measures may lead to fewer projected boilers and process heaters. This trend would lead to an overestimate (upward bias) of the impact estimates presented in this report.

2. *Estimate the number of new boilers by model number-fuel type.* To predict the number of new boilers in operation by 2005, EPA applied the percentage difference for each fuel category to the 1998 fuel consumption of boilers represented by the boiler models to calculate total energy consumed by boilers in 2005 for each model number. The number of new boilers per model was calculated by dividing the model fuel forecasts by the annual fuel consumption of one unit and then subtracting the number of units present in 1998, as follows:

$$\begin{array}{c}\text{Number of} \\ \text{New Units}\end{array} = \left(\frac{\text{Total energy consumed (2005) [MMBtu/yr]}}{\text{Avg capacity [MMBtu/hr]} \times 8{,}760 \text{ [hr/yr]}} \right) - \begin{array}{c}\text{Number of} \\ \text{Units}\end{array} \ (1998)$$

Following these steps, EPA projects that 1,458 boilers and 374 process heaters to be installed between 1998 and 2005 will be affected by the new source MACT floor and the Option 1A alternative. The only new ICI boilers and process heaters that will be unaffected are those natural gas and distillate fuel units that have input capacities less than 10 MMBtu/hr. These projections were developed by model unit type, not by industry. To assess the distribution of the boilers and process heaters estimated to be operating in 2005 across industries, EPA attached unit-level weights by model number to each unit in the Inventory Database. These weights allow each unit in the Inventory Database to represent a number (or fraction) of units that are predicted to be in use by the end of 2005. The weights were then summed by two-digit SIC code to estimate the distribution of units by industry.

Table 3-6 presents the projected number of new boilers and process heaters for the MACT floor and Option1A above-the-floor alternatives. Industries with the estimated greatest concentrations of new units include chemicals and allied products (295), petroleum refining (198), electric services (134), and paper and allied products (96). New source estimates by industry were not developed for the Option 1B above-the-floor alternative.

3.4 National Engineering Population, Cost Estimates, and Cost-Effectiveness Estimates

The Agency estimates that in 2005 5,562 units (existing units and new units) may be affected by the floor alternative and 9,163 units may be affected by the Option 1A above-the-floor alternative. These populations were used to estimate national engineering costs. The population estimates were determined by unit configuration, not by industry. Thus, the distribution of units by industry shown in Tables 3-6 and 3-7 was determined by weighting existing units by the estimates by unit configuration and tallying weighted units by SIC code. The average cost of control by unit configuration was multiplied by the weighted number of units to determine industry-level control cost estimates.

Table 3-8 presents industry-level population and cost estimates for boilers and process heaters for both the floor and above-the-floor alternatives. The distribution of weighted units across industries mirrors that of the analysis population even though it was determined by weighting units by configuration, not industry-level growth estimates. The floor cost of control for the estimated 5,562 boilers and process heaters is $863.0 million, with an average per-unit additional control cost of $155,157. The Option 1A cost of control for the 9,163 potentially affected units is $1,995.8 million, with an average per-unit cost of $217,811.

The Agency estimates that Option 1B will potentially affect 62,215 boilers and process heaters. The Option 1B cost of control for the 62,215 potentially affected units is $2,944.8 million. Option 1B costs are not presented by industry because approximately one-third of the units did not have SIC code (and, hence, no NAICS code) information.

To provide additional information on the magnitude of the cost estimates, Table 3-5 shows the cost-effectiveness (cost/ton reduced estimates) for the HAP and non-HAP pollutants whose emissions are reduced by this rule.

Table 3-5. Cost Effectiveness (C/E) of Industrial Boiler and Process Heater MACT on Existing Units and Subcategories.

	Total Annualized Costs	Large Solid fuel Subcategory	Large Solid fuel Subcategory - Coal Only	Large Solid fuel Subcategory - Wood Only	Limited Use Solid fuel Subcategory
Control Costs ($)	833,273,781[b]	810,422,230	669,353,690	141,068,540	22,851,551
PM Emissions Reduction (Tons/Year)	565,900	563,060	359,920	203,140	2,840
C/E ($/ton PM)	1,472[a]	1,439	1,860	694	8,046
Metals Emissions Reduction (Tons/Year)	1,093	1,087	591	496	6
C/E ($/ton metals)	762,373[a]	745,558[a]	1,132,578[a]	284,412[a]	3,808,592[a]
HCl Emissions Reduction (Tons/Year)	46,515	46,515	45,136	1,379	---

C/E ($/ton HCl)	17,914[a]	17,422[a]	14,830[a]	102,298[a]	---
HAP Emissions Reduction (Tons/Year)	47,608	47,602	45,727	1,875	6
C/E ($/ton HAP)	**17,502**	**17,025**	**14,638**	**75,236**	**3,808,500**

[a] The cost-effectiveness value is based on the total annualized cost of the rule and not on the cost for controlling the specific pollutant, and, thus, overstates the cost/ton for the specific HAP or other pollutant.

[b] Costs are in 1999 dollars. Emission reductions are calculated for 2005.

Table 3-6. New Unit Projections by Industry, MACT Floor and Option 1A Alternatives

SIC	NAICS		Floor Alternative		Option 1A Alternative	
Code	Code	Description	New Units	Cost	New Units	Cost
01	111	Agriculture—Crops	—	—	—	—
02	112	Agriculture—Livestock	—	—	—	—
07	115	Agricultural Services	—	—	—	—
10	212	Metal Mining	6	$47,040	6	$47,040
12	212	Coal Mining	1	$7,840	1	$7,840
13	211	Oil and Gas Extraction	89	$697,760	89	$697,760
14	212	Mining/Quarrying—Nonmetallic Minerals	6	$87,740	6	$87,740
17	235	Construction—Special Trade Contractors	—	—	—	—
20	311	Food and Kindred Products	63	$801,836	63	$11,170,931
21	312	Tobacco Products	7	$54,880	7	$54,880
22	313	Textile Mill Products	73	$1,329,391	73	$1,463,682
23	315	Apparel and Other Products from Fabrics	—	—	—	—
24	321	Lumber and Wood Products	61	$1,748,655	61	$10,621,232
25	337	Furniture and Fixtures	47	$1,354,701	47	$4,306,979
26	322	Paper and Allied Products	96	$1,526,704	96	$15,984,332
27	511	Printing, Publishing, and Related Industries	19	$148,960	19	$148,960
28	325	Chemicals and Allied Products	295	$3,793,738	295	$3,883,243
29	324	Petroleum Refining and Related Industries	198	$1,552,320	198	$1,552,320
30	326	Rubber and Miscellaneous Plastics Products	44	$385,660	44	$385,660
31	316	Leather and Leather Products	5	$39,200	5	$39,200
32	327	Stone, Clay, Glass, and Concrete Products	37	$549,975	37	$549,975
33	331	Primary Metal Industries	80	$2,873,492	80	$2,873,492
34	332	Fabricated Metal Products	53	$496,920	53	$496,920
35	333	Industrial Machinery and Computer Equipment	35	$396,500	35	$396,500
36	335	Electronic and Electrical Equipment	40	$313,600	40	$313,600
37	336	Transportation Equipment	80	$1,133,423	80	$1,357,219
38	334	Scientific, Optical, and Photographic Equipment	11	$86,240	11	$86,240
39	339	Miscellaneous Manufacturing Industries	9	$162,323	9	$254,722
40	482	Railroad Transportation	—	—	—	—
42	484	Motor Freight and Warehousing	1	$48,540	1	$48,540

(continued)

Table 3-6. New Unit Projections by Industry, MACT Floor and Option 1A Alternatives (continued)

SIC Code	NAICS Code	Description	Floor Alternative		Option 1A Alternative	
			New Units	Cost	New Units	Cost
46	486	Pipelines, Except Natural Gas	1	$7,840	1	$7,840
49	221	Electric, Gas, and Sanitary Services	134	$2,094,546	134	$10,490,757
50	421	Wholesale Trade—Durable Goods	—	—	—	—
51	422	Wholesale Trade—Nondurable Goods	—	—	—	—
55	441	Automotive Dealers and Gasoline Service Stations	—	—	—	—
58	722	Eating and Drinking Places	—	—	—	—
59	445–454	Miscellaneous Retail	—	—	—	—
60	522	Depository Institutions	—	—	—	—
70	721	Hotels and Other Lodging Places	—	—	—	—
72	812	Personal Services	1	$7,840	1	$7,840
76	811	Miscellaneous Repair Services	—	—	—	—
80	621	Health Services	6	$209,840	6	$209,840
81	541	Legal Services	—	—	—	—
82	611	Educational Services	19	$815,855	19	$815,855
83	624	Social Services	—	—	—	—
86	813	Membership Organizations	—	—	—	—
87	541	Engineering, Accounting, Research, Management and Related Services	2	$388,350	2	$388,350
89	711/514	Services, N.E.C.	—	—	—	—
91	921	Executive, Legislative, and General Administration	—	—	—	—
92	922	Justice, Public Order, and Safety	4	$153,460	4	$153,460
94	923	Administration of Human Resources	—	—	—	—
96	926	Administration of Economic Programs	—	—	—	—
97	928	National Security and International Affairs	2	$97,080	2	$97,080
NA		SIC Information Not Available	307	$2,497,327	307	$2,586,832
State		Parent is a State Government	—	—	—	—
			1,832	$25,909,574	1,832	$71,586,861

Table 3-7. Unit Cost and Population Estimates for the Floor Alternative by Industry, 2005

SIC Code	NAICS Code	Description	Total Units: Floor Units	Total Units: Percent	Total Cost: Floor Costs (by Unit)	Total Cost: Percent
01	111	Agriculture—Crops	5	0.08%	$628,943	0.07%
02	112	Agriculture—Livestock	—	0.00%	—	0.00%
07	115	Agricultural Services	—	0.00%	—	0.00%
10	212	Metal Mining	27	0.48%	$6,651,678	0.77%
12	212	Coal Mining	6	0.10%	$683,026	0.08%
13	211	Oil and Gas Extraction	89	1.60%	$697,760	0.08%
14	212	Mining/Quarrying—Nonmetallic Minerals	25	0.46%	$8,253,479	0.96%
17	235	Construction—Special Trade Contractors	—	0.00%	—	0.00%
20	311	Food and Kindred Products	312	5.60%	$37,774,020	4.38%
21	312	Tobacco Products	28	0.51%	$6,014,216	0.70%
22	313	Textile Mill Products	360	6.47%	$74,152,804	8.59%
23	315	Apparel and Other Products from Fabrics	4	0.08%	$679,510	0.08%
24	321	Lumber and Wood Products	483	8.68%	$48,896,055	5.67%
25	337	Furniture and Fixtures	311	5.59%	$29,632,880	3.43%
26	322	Paper and Allied Products	565	10.15%	$123,008,263	14.25%
27	511	Printing, Publishing, and Related Industries	19	0.34%	$148,960	0.02%
28	325	Chemicals and Allied Products	644	11.58%	$116,236,183	13.47%
29	324	Petroleum Refining and Related Industries	217	3.91%	$4,620,563	0.54%
30	326	Rubber and Miscellaneous Plastics Products	73	1.32%	$6,356,835	0.74%
31	316	Leather and Leather Products	7	0.13%	$607,530	0.07%
32	327	Stone, Clay, Glass, and Concrete Products	57	1.02%	$6,253,678	0.72%
33	331	Primary Metal Industries	159	2.85%	$27,110,619	3.14%
34	332	Fabricated Metal Products	87	1.56%	$10,042,680	1.16%
35	333	Industrial Machinery and Computer Equipment	84	1.51%	$11,208,392	1.30%
36	335	Electronic and Electrical Equipment	52	0.93%	$3,744,828	0.43%
37	336	Transportation Equipment	300	5.39%	$55,440,341	6.42%
38	334	Scientific, Optical, and Photographic Equipment	26	0.46%	$3,511,206	0.41%
39	339	Miscellaneous Manufacturing Industries	12	0.22%	$826,346	0.10%
40	482	Railroad Transportation	9	0.16%	$1,251,062	0.14%
42	484	Motor Freight and Warehousing	12	0.22%	$2,128,148	0.25%

(continued)

Table 3-7. Unit Cost and Population Estimates for the Floor Alternative by Industry, 2005 (continued)

			Total Units		Total Cost	
SIC Code	NAICS Code	Description	Floor Units	Percent	Floor Costs (by Unit)	Percent
46	486	Pipelines, Except Natural Gas	1	0.02%	$7,840	0.00%
49	221	Electric, Gas, and Sanitary Services	718	12.91%	$150,341,645	17.42%
50	421	Wholesale Trade—Durable Goods	6	0.12%	$2,154,760	0.25%
51	422	Wholesale Trade—Nondurable Goods	4	0.07%	$1,673,511	0.19%
55	441	Automotive Dealers and Gasoline Service Stations	—	0.00%	—	0.00%
58	722	Eating and Drinking Places	—	0.00%	—	0.00%
59	445–454	Miscellaneous Retail	—	0.00%	—	0.00%
60	522	Depository Institutions	—	0.00%	—	0.00%
70	721	Hotels and Other Lodging Places	2	0.04%	$567,811	0.07%
72	812	Personal Services	1	0.02%	$7,840	0.00%
76	811	Miscellaneous Repair Services	4	0.08%	$625,531	0.07%
80	621	Health Services	86	1.55%	$15,172,212	1.76%
81	541	Legal Services	—	0.00%	—	0.00%
82	611	Educational Services	251	4.52%	$60,490,956	7.01%
83	624	Social Services	5	0.08%	$820,191	0.10%
86	813	Membership Organizations	—	0.00%	—	0.00%
87	541	Engineering, Accounting, Research, Management and Related Services	38	0.68%	$2,240,544	0.26%
89	711/514	Services, N.E.C.	2	0.04%	$918,360	0.11%
91	921	Executive, Legislative, and General Administration	2	0.04%	$312,765	0.04%
92	922	Justice, Public Order, and Safety	69	1.23%	$13,707,649	1.59%
94	923	Administration of Human Resources	2	0.04%	$314,316	0.04%
96	926	Administration of Economic Programs	8	0.15%	$2,300,308	0.27%
97	928	National Security and International Affairs	64	1.16%	$18,018,010	2.09%
NA		SIC Information Not Available	326	5.86%	$6,747,652	0.78%
State		Parent is a state government	—	0.00%	—	0.00%
			5,562		$862,981,906	

Table 3-8. Unit Cost and Population Estimates for the Option 1A Above-the-Floor Alternative by Industry, 2005

			Total Units		Total Cost	
SIC Code	NAICS Code	Description	Option 1A Units	Percent	Option 1A Costs (by Unit)	Percent
01	111	Agriculture—Crops	11	0.12%	$1,633,841	0.08%
02	112	Agriculture—Livestock	—	0.00%	—	0.00%
07	115	Agricultural Services	—	0.00%	—	0.00%
10	212	Metal Mining	34	0.37%	$8,952,098	0.45%
12	212	Coal Mining	6	0.06%	$683,026	0.03%
13	211	Oil and Gas Extraction	137	1.50%	$6,070,001	0.30%
14	212	Mining/Quarrying—Nonmetallic Minerals	31	0.34%	$17,958,177	0.90%
17	235	Construction—Special Trade Contractors	2	0.03%	$230,525	0.01%
20	311	Food and Kindred Products	376	4.10%	$122,487,346	6.14%
21	312	Tobacco Products	56	0.61%	$13,685,614	0.69%
22	313	Textile Mill Products	673	7.34%	$147,094,726	7.37%
23	315	Apparel and Other Products from Fabrics	10	0.11%	$1,213,586	0.06%
24	321	Lumber and Wood Products	620	6.77%	$89,961,854	4.51%
25	337	Furniture and Fixtures	421	4.60%	$50,045,573	2.51%
26	322	Paper and Allied Products	1,050	11.46%	$323,736,302	16.22%
27	511	Printing, Publishing, and Related Industries	37	0.40%	$1,824,933	0.09%
28	325	Chemicals and Allied Products	1,359	14.83%	$293,027,205	14.68%
29	324	Petroleum Refining and Related Industries	677	7.38%	$73,172,001	3.67%
30	326	Rubber and Miscellaneous Plastics Products	178	1.94%	$18,100,195	0.91%
31	316	Leather and Leather Products	66	0.72%	$6,924,480	0.35%
32	327	Stone, Clay, Glass, and Concrete Products	154	1.68%	$17,509,996	0.88%
33	331	Primary Metal Industries	271	2.95%	$65,174,064	3.27%
34	332	Fabricated Metal Products	165	1.80%	$22,066,661	1.11%
35	333	Industrial Machinery and Computer Equipment	151	1.65%	$26,418,385	1.32%
36	335	Electronic and Electrical Equipment	167	1.82%	$18,770,867	0.94%
37	336	Transportation Equipment	453	4.95%	$107,402,909	5.38%
38	334	Scientific, Optical, and Photographic Equipment	104	1.13%	$13,638,983	0.68%
39	339	Miscellaneous Manufacturing Industries	37	0.41%	$4,222,427	0.21%
40	482	Railroad Transportation	9	0.10%	$2,240,871	0.11%
42	484	Motor Freight and Warehousing	19	0.21%	$3,475,610	0.17%

(continued)

Table 3-8. Unit Cost and Population Estimates for the Option 1A Above-the-Floor Alternative by Industry, 2005 (continued)

			Total Units		Total Cost	
SIC Code	NAICS Code	Description	Option 1A Units	Percent	Option 1A Costs (by Unit)	Percent
46	486	Pipelines, Except Natural Gas	19	0.21%	$1,959,589	0.10%
49	221	Electric, Gas, and Sanitary Services	865	9.44%	$331,479,389	16.61%
50	421	Wholesale Trade—Durable Goods	6	0.07%	$2,675,296	0.13%
51	422	Wholesale Trade—Nondurable Goods	4	0.04%	$2,693,380	0.13%
55	441	Automotive Dealers and Gasoline Service Stations	2	0.02%	$195,421	0.01%
58	722	Eating and Drinking Places	—	0.00%	—	0.00%
59	445–454	Miscellaneous Retail	3	0.03%	$259,585	0.01%
60	522	Depository Institutions	—	0.00%	—	0.00%
70	721	Hotels and Other Lodging Places	2	0.02%	$849,114	0.04%
72	812	Personal Services	1	0.01%	$7,840	0.00%
76	811	Miscellaneous Repair Services	4	0.05%	$1,120,435	0.06%
80	621	Health Services	93	1.01%	$22,545,605	1.13%
81	541	Legal Services	—	0.00%	—	0.00%
82	611	Educational Services	273	2.98%	$91,770,778	4.60%
83	624	Social Services	8	0.08%	$1,448,405	0.07%
86	813	Membership Organizations	—	0.00%	—	0.00%
87	541	Engineering, Accounting, Research, Management and Related Services	49	0.54%	$5,016,627	0.25%
89	711/514	Services, N.E.C.	2	0.02%	$1,211,582	0.06%
91	921	Executive, Legislative, and General Administration	5	0.06%	$845,423	0.04%
92	922	Justice, Public Order, and Safety	77	0.85%	$21,308,885	1.07%
94	923	Administration of Human Resources	2	0.02%	$314,316	0.02%
96	926	Administration of Economic Programs	8	0.09%	$4,200,975	0.21%
97	928	National Security and International Affairs	96	1.05%	$36,080,306	1.81%
NA		SIC Information Not Available	368	4.01%	$12,099,975	0.61%
State		Parent is a state government	—	0.00%	—	0.00%
			9,163		$1,995,805,181	

References

Eastern Research Group. Memorandum to Jim Eddinger, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Development of the Population Database for the Industrial/Commercial/Institutional Boiler and Indirect-Fired Process Heater National Emission Standard for Hazardous Air Pollutants (NESHAP). May 18, 2000.

Eastern Research Group. Memorandum to Jim Eddinger, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Development of Model Units for the Industrial/Commercial/Institutional Boiler and Indirect-Fired Process Heater National Emission Standard for Hazardous Air Pollutants (NESHAP). July, 2000.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Industrial Combustion Coordinated Rulemaking, Inventory Database V4.1- Boilers. February 26, 1999.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Industrial Combustion Coordinated Rulemaking, Inventory Database V4 - Process Heaters. November 13, 1998.

CHAPTER 4

PROFILES OF AFFECTED INDUSTRIES

This chapter contains profiles of the major industries affected by the MACT for industrial boilers and process heaters. Included are profiles of the following industries:

- Textile Mill Products (SIC 22/NAICS 313)
- Lumber and Wood Products (SIC 24/NAICS 321)
- Furniture and Related Product Manufacturing (SIC 25/NAICS 337)
- Paper and Allied Products (SIC 26/NAICS 322)
- Medicinal Chemicals and Botanical Products and Pharmaceutical Preparations (SICs 2833, 2834/NAICS 32451)
- Industrial Organic Chemicals (SIC 2869/NAICS 3251)
- Electric Services (SIC 4911/NAICS 22111)

4.1 Textile Mill Products (SIC 22/NAICS 313)

The textile industry is one of the few industries found throughout the world, from the most industrialized countries to the poorest. This industry includes firms producing the following products: broadwoven fabric; weft, lace, and warp knit fabrics; carpets and rugs; spun yarn products; and man-made fibers. The United States has typically run a trade deficit in the textiles sector in recent years, importing about $1.3 billion more than was exported in 1995. Although trade has become an increasingly important part of this industry, trade in this segment is relatively small compared with trade in the downstream apparel segment. In 1996, the total value of shipments for the textile industry was $80,242 million.

4.2 Lumber and Wood Products (SIC 24/NAICS 321)

The lumber and wood products industry comprises a large number of establishments engaged in logging; operating sawmills and planing mills; and manufacturing structural wood panels, wooden containers, and other wood products. Table 4-1 lists the lumber and wood products markets that are likely to be affected by the regulation on boilers. Most products are produced for the domestic market, but exports increasingly account for a larger proportion of sales (Haltmaier, 1998). The largest consumers of lumber and wood products are the remodeling and construction industries.

Table 4-1. Lumber and Wood Products Markets Likely to Be Affected by the Regulation

SIC	NAICS	Description
2421	321113	Sawmills and Planing Mills, General
2434	33711	Wood Kitchen Cabinets
2449	32192	Wood Containers, N.E.C.
2491	32114	Wood Preserving
2493	321219	Reconstituted Wood Products
2499	321999	Wood Products, N.E.C.

Source: Industrial Combustion Coordinated Rulemaking (ICCR). 1998. Data/Information Submitted to the Coordinating Committee at the Final Meeting of the Industrial Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

In 1996, the lumber and wood products industry's total value of shipments was $85,724.0 million. As seen in Table 4-2, shipment values increased steadily through the late 1980s before declining slightly through the early 1990s as new construction starts and furniture purchases declined (Haltmaier, 1998). Shipment values recovered, however, as the economy expanded in the mid-1990s.

4.2.1 Supply Side of the Industry

This section describes the lumber industry's production processes, output, costs of production, and capacity utilization.

4.2.1.1 Production Processes

Sawn lumber. Sawn lumber is softwood or hardwood trimmed at a sawmill for future uses in construction, flooring, furniture, or other markets. Softwoods, such as Douglas fir and spruce, are used for framing in residential or light-commercial construction. Hardwoods, such as maple and oak, are used in flooring, furniture, crating, and other applications.

Lumber is prepared at mills using a four-step process. First, logs are debarked and trimmed into cants, or partially finished lumber. The cants are then cut to specific lengths. Logs are generally kept wet during storage to prevent cracking and to keep them supple. However, after being cut, the boards undergo a drying process, either in open air or in a kiln, to reduce the moisture content. The drying process may take several months and varies according to the plant's climate and the process used. Finally, the lumber may be treated with a surface protectant to prevent sap stains and prepare it for export (EPA, 1995a).

Reconstituted wood products. Reconstituted wood products, such as particleboard, medium density fiberboard, hardboard, and oriented strandboard, are made from raw wood that is combined with resins and other additives and processed into boards. The size of the wood particles used varies from sawdust to strands of wood. Once combined, the ingredients are formed into a mat and then, at high temperatures, pressed into a board. A final finishing process prepares the boards for delivery.

Wood preserving. Wood is treated with preservative to protect it from mechanical, physical, and chemical influences (EPA, 1995a). Treatment agents are either water-based inorganics, such as copper arsenate (78 percent), or oil-borne organics, such as creosote (21 percent) (EPA, 1995a). Wood

Table 4-2. Value of Shipments for the Lumber and Wood Products Industry (SIC 24/NAICS 321), 1987-1996

Year	Value of Shipments (1992 $\$10^6$)
1987	85,383.4
1988	85,381.2
1989	85,656.8
1990	86,203.0
1991	81,666.0
1992	81,564.8
1993	74,379.6
1994	79,602.0
1995	87,574.6
1996	85,724.0

Sources: U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures [Multiple Years]*. Washington, DC: Government Printing Office.

preservatives are usually applied using a pressure treatment process or a dipping tank. Producers achieve the best results when the lumber's moisture content is reduced to a point where the preservative can be easily soaked into the wood. Treated wood is then placed in a kiln or stacked in a low-humidity climate to dry.

4.2.1.2 Types of Output

The lumber and wood products industry produces essential inputs into the construction, remodeling, and furniture sectors. Lumber and reconstituted wood products are produced in an array of sizes and can be treated to enhance their value and shelf-life. These products are intermediate goods; they are purchased by other industries and incorporated into higher value-added products. In addition to sawmills, the lumber and wood products industry includes kitchen cabinets, wood containers, and other wooden products used for fabricating finished goods for immediate consumption.

4.2.1.3 Major By-Products and Co-Products

Shavings, sawdust, and wood chips are the principal co-products of sawn lumber. Paper mills and makers of reconstituted wood products frequently purchase this material as an input. By-products are limited to emissions from the drying process and from use of preservatives.

Very little solid waste is generated by reconstituted wood products manufacturing. Because the production process incorporates all parts of the sawn log, little is left over as waste. However, air emissions from dryers are a source of emissions.

Wood preserving results in two types of by-products: air emissions and process debris. As preservatives dry, either in a kiln or outside, they emit various chemicals into the air. At plants with dipping processes, wood chips, stones, and other debris build up in the dipping tank. The debris is routinely collected and disposed of.

4.2.1.4 Costs of Production

The costs of production for the wood products industry fluctuate with the demand for the industry's products. Most notably, the costs of production steadily declined during the early 1990s as recession stifled furniture purchases and new housing starts (see Table 4-3). Overall, employment in the lumber and wood products industry increased approximately 6 percent from 1987 to 1996. During this same period, payroll costs decreased 12 percent, indicating a decrease in average annual income per employee. New capital investment and costs of materials generally moved in tandem over the 10-year period, increasing from 1987 to 1990 and 1994 to 1996 and decreasing from 1991 to 1993.

4.2.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of the actual production level to the full production level. Table 4-4 presents the historical trends in capacity utilization for the lumber and wood products industry. The varying capacity utilization ratios reflect adjusting production levels and new production facilities going on- or off-line. The capacity utilization ratio for the industry in 1996 was 78; the average over the last 6 years was 79 percent.

4.2.2 Demand Side of the Industry

This section describes the demand side of the market, including product characteristics, the uses and consumers of the final products, organization of the industry, and markets and trends.

4.2.3 Product Characteristics

Lumber and wood products are valued both for their physical attributes and their relative low cost. Wood is available in varying degrees of durability, shades, and sizes and can be easily shaped. Lumber and wood products have long been the principal raw materials for the residential and light commercial construction industries, the remodeling industry, and the furniture industry.

Table 4-3. Inputs for the Lumber and Wood Products Industry (SIC 24/NAICS 321), 1987–1996

	Labor			
Year	Quantity (10^3)	Payroll (1992 $\$10^6$)	Materials (1992 $\$10^6$)	New Capital Investment (1992 $\$10^6$)
1987	698.4	15,555.5	50,509.2	2,234.3
1988	702.4	15,800.0	51,341.0	2,099.4
1989	684.2	15,381.3	51,742.2	2,329.9
1990	677.7	15,612.9	53,369.0	2,315.3
1991	623.6	14,675.8	50,416.3	2,006.5
1992	655.8	13,881.8	48,570.0	1,760.1
1993	685.4	11,798.9	45,300.3	1,538.1
1994	718.5	12,212.5	48,535.6	1,956.8
1995	740.2	13,915.4	53,732.9	2,553.1
1996	738.7	13,933.7	52,450.1	2,659.9

Sources: U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures [Multiple Years]*. Washington, DC: Government Printing Office.

Table 4-4. Capacity Utilization Ratios for Lumber and Wood Products Industry, 1991-1996

1991	1992	1993	1994	1995	1996
78	80	81	80	77	78

Note: All values are percentages.

Source: U.S. Department of Commerce, Bureau of the Census. 1998. *Survey of Plant*

Wood is readily available because over one-third of the United States is forested. The ready supply of wood reduces its costs.

4.2.4 Uses and Consumers of Outputs

Lumber and wood products are used in a wide range of applications, including residential and noresidential construction; repair/remodeling and home improvement projects; manufactured housing; millwork and wood products; pulp, paper, and paperboard mills; toys and sporting goods; kitchen cabinets; crates and other wooden containers; office and household furniture; and motor homes and recreational vehicles (Haltmaier, 1998).

4.2.5 Organization of the Industry

In 1992, 33,878 companies produced lumber and wood products and operated 35,807 facilities, as shown in Table 4-5. By way of comparison, in 1987, 32,014 companies controlled 33,987 facilities. About two-thirds of all establishments have nine or fewer employees. Between 1987 and 1992, the number of facilities with nine or fewer employees increased more than 10 percent to 23,590. These facilities' share of the value of shipments increased about 18.3 percent. Although the number of establishments employing 100 to 249 people decreased during that time, that category's shipment value jumped nearly 40 percent. The remaining facility categories lost both facilities and value of shipment.

Market structure can affect the size and distribution of regulatory impacts. Concentration ratios are often used to evaluate the degree of competition in a market, with low concentration indicating the presence of a competitive market, and higher concentration suggesting less-competitive markets. Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to influence market prices. Typical measures include four- and eight-firm concentration ratios (CR4 and CR8) and Herfindahl-Hirschmann indices (HHI). The CR4 for lumber and wood products subsectors represented in the boilers inventory database ranges between 13 and 50, meaning that, in each subsector, the top firms' combined sales ranged from 13 to 50 percent of that respective subsector's total sales. The CR8 ranges from 47 to 66 (U.S. Department of Commerce, 1995d).

Although there is no objective criterion for determining market structure based on the values of concentration ratios, the 1992 Department of Justice's (DOJ's) Horizontal Merger Guidelines provide

Table 4-5. Size of Establishments and Value of Shipments for the Lumber and Wood Products Industry (SIC 24/NAICS 321)

Average Number of Employees in Establishment	1987 Number of Facilities	1987 Value of Shipments (1992 $\$10^6$)	1992 Number of Facilities	1992 Value of Shipments (1992 $\$10^6$)
1 to 4 employees	14,562	2,769.7	15,921	3,288.9
5 to 9 employees	6,702	4,264.4	7,669	5,030.4
10 to 19 employees	5,353	6,982.3	5,331	6,902.8
20 to 49 employees	4,160	28,551.3	3,924	26,964.9
50 to 99 employees	1,702	(D)	1,615	(D)
100 to 249 employees	1,190	24,583.3	1,082	34,051.4
250 to 499 employees	260	12,093.4	219	(D)
500 to 999 employees	47	3,907.9	39	3,331.4
1,000 to 2,499 employees	4	2,231.3	4	598.6
2,500 or more employees	2	(D)	3	1,396.4
Total	33,987	85,383.4	35,807	81,564.8

(D) = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1991. *1987 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.

criteria for doing so based on HHIs. According to these criteria, industries with HHIs below 1,000 are

Table 4-6. Measures of Market Concentration for Lumber and Wood Products Markets

SIC	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
2421	Saw Mills and Planing Mills	14	20	78	5,302	6004
2434	Wood Kitchen Cabinets	19	25	156	4,303	4323
2449	Wood Containers, N.E.C.	34	47	414	217	225
2491	Wood Preserving	17	28	152	408	486
2493	Reconstituted Wood Products	50	66	765	193	288
2499	Wood Products, N.E.C.	13	19	70	2,656	2754

Sources: U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary.* Washington, DC: Government Printing Office.

considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive) (DOJ, 1992). Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to be able to influence market prices. The unconcentrated nature of the markets is also indicated by HHIs of 1,000 or less (DOJ, 1992). Table 4-6 presents various measures of market concentration for sectors within the lumber and wood products industry. All lumber and wood products industries are considered unconcentrated and competitive.

4.2.6 Markets and Trends

The U.S. market for lumber and wood products is maturing, and manufacturers are looking to enter other markets. Although 91 percent of the industry's products are consumed by the U.S. domestic market, the share of exports increases each year. Exports more than doubled in value from $3 billion in 1986 to $7.3 billion in 1996 (Haltmaier, 1998). The U.S. market grew only 2 percent between 1986 and 1996. American manufacturers are focusing on growing construction markets in Canada, Mexico, and the Pacific Rim, with products such as durable hardwood veneer products and reconstituted wood boards (EPA, 1995a).

4.3 Furniture and Related Product Manufacturing (SIC 25/NAICS 337)

More than 20,000 establishments in the United States produce furniture and furniture-related products. These establishments are located across the United States but are traditionally most concentrated in southern states, such as North Carolina, Mississippi, Alabama, and Tennessee. According to the "1997 Economic Census," these establishments employed more than 600,000 people and paid annual wages of nearly $15 billion. The overall industry-wide value of shipments was $63.9 billion that year (U.S. Department of Commerce, 2001).

This industry is in a state of change: rapid U.S. economic growth translated into vigorous sales of household and office funiture, but this trend is unlikely to continue as the U.S. economy cools after its record run. Adding to industry fluctuation is the merger of two large firms, Lay-Z-Boy and LADD Furniture. Although the industry includes a multitude of niche market players, it is really dominated by a few large companies that operate several subsidiaries, each with its own brand identity. It is unclear whether the merger between two key players in the market will compel other large manufacturers to pursue mergers and acquisitions.

What is clear, however, is that large U.S. manufacturers will seek to leverage their brand identities into wider profit margins by operating direct sales establishments and co-branding. Manufacturers that are moving into retail and distribution include Bassett Furniture, Thomasville Furniture, Ethan Allen Interiors, and Drexel. Co-branding efforts are aimed at capitalizing on the combined power of two identities, such as the Thomas Kinkade Collection from Lay-Z-Boy and popular artist Thomas Kinkade and the Ernest Hemingway Collection from Thomasville. The overarching goal is to enhance margins and ward off invigorated competition from foreign companies that have used this strategy to capture U.S. market share, such as the Swedish manufacturer Ikea (Lemm, 2000).

U.S. imports of household furniture totaled nearly $7 billion in 1998. Between 1992 and 1998, furniture imports grew at an annualized rate of nearly 15 percent. Jamie Lemm, an analyst with the U.S. Department of Commerce's Office of Consumer Goods attributes this growth to changes in U.S. manufacturing and markets:

> A portion of [the] increase can be attributed to the labor-intensive furniture parts imported by U.S. manufacturers to enhance product lines, but the increase also signifies the growing importance of the U.S. market to foreign firms. While some U.S. manufacturers operate showrooms, galleries, and retail outlets in foreign markets, few sell internationally on a large scale. In 1998, U.S. furniture exports totaled $1.6 billion, accounting for only 6 percent of all U.S. product shipments.

4.4 Paper and Allied Products (SIC 26/NAICS 322)

The paper and allied products industry is one of the largest manufacturing industries in the United States. In 1996, the industry shipped nearly $150 billion in paper commodities. The industry produces a wide range of wood pulp, primary paper products, and paperboard products such as printing and writing papers, industrial papers, tissues, container board, and boxboard. The industry also includes manufacturers that "convert" primary paper and paperboard into finished products like envelopes, packaging, and shipping containers (EPA, 1995b). Paper and allied products industry subsectors that are likely to be affected by the proposed regulation are listed in Table 4-7.

Table 4-7. Paper and Allied Products Industry Markets Likely to Be Affected by Regulation

SIC	NAICS	Industry Description
2611	32211	Pulp Mills
2621	32212	Paper Mills
2676	322291	Sanitary Paper Products

Source: Industrial Combustion Coordinated Rulemaking (ICCR). 1998. Data/Information Submitted to the Coordinating Committee at the Final Meeting of the Industrial Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

Table 4-8 lists the paper and allied products industry's value of shipments from 1987 to 1996. The industry's performance is tied to raw material prices, labor conditions, and worldwide inventories and demand (EPA, 1995b). Performance over the 10-year period was typical of most manufacturing industries. The industry expanded in the late 1980s, then contracted as demand tapered off as the industry suffered recessionary effects. In the two years after 1994, the industry's value of shipments increased 9.3 percent to $149.5 billion.

4.4.1 Supply Side of the Industry

4.4.1.1 Production Process

The manufacturing paper and allied products industry is capital- and resource-intensive, consuming large amounts of pulp wood and water in the manufacturing process. Approximately half of all paper and allied products establishments are integrated facilities, meaning that they produce both pulp and paper on-site. The remaining half produce only paper products; few facilities produce only pulp (EPA, 1995b).

Table 4-8. Value of Shipments for the Paper and Allied Products Industry (SIC 26/NAICS 322), 1987–1996

Year	Value of Shipments (1992 $\$10^6$)
1987	129,927.8
1988	136,829.4
1989	138,978.3
1990	136,175.7
1991	132,225.0
1992	133,200.7
1993	131,362.2
1994	136,879.9
1995	135,470.3
1996	149,517.1

Sources: U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures, [Multiple Years]*. Washington, DC: Government Printing Office.

The paper and paperboard manufacturing process can be divided into three general steps: pulp making, pulp processing, and paper/paperboard production. Paper and paperboard are manufactured using what is essentially the same process. The principal difference between the two products is that paperboard is thicker than paper's 0.3 mm.

Producers manufacture pulp mixtures by using chemicals, machines, or both to reduce raw material into small fibers. In the case of wood, the most common pulping material, chemical pulping actions release cellulose fibers by selectively destroying the chemical bonds that bind the fibers together (EPA, 1995b). Impurities are removed from the pulp, which then may be bleached to improve brightness. Only about 20 percent of pulp and paper mills practice bleaching (EPA, 1995b). The pulp may also be further processed to aid in the paper-making process.

During the paper-making stage, the pulp is strengthened and then converted into paper. Pulp can be combined with dyes, resins, filler materials, or other additives to better fulfill specifications for the final product. Next, the water is removed from the pulp, leaving the pulp on a wire or wire mesh conveyor. The fibers bond together as they are carried through heated presses and rollers. The paper is stored on large rolls before being shipped for conversion into another product, such as envelopes and boxes, or cut into paper sheets for immediate consumption.

4.4.1.2 Types of Output

The paper and allied products industry's output ranges from writing papers to containers and packaging. Paper products include printing and writing papers; paperboard boxes; corrugated and solid

Table 4-9. Inputs for the Paper and Allied Products Industry (SIC 26/NAICS 322), 1987–1996

Year	Labor: Quantity (10^3)	Labor: Payroll (1992 $$10^6$)	Materials (1992 $$10^6$)	New Capital Investment (1992 $$10^6$)
1987	611.1	20,098.6	70,040.6	6,857.5
1988	619.8	19,659.0	73,447.4	8,083.8
1989	633.2	19,493.1	75,132.5	10,092.9
1990	631.2	19,605.2	74,568.8	11,267.2
1991	624.7	19,856.3	72,602.5	9,353.9
1992	626.3	20,491.9	73,188.0	7,962.4
1993	626.3	20,602.6	73,062.6	7,265.2
1994	621.4	20,429.7	76,461.6	6,961.7
1995	629.2	18,784.3	79,968.6	7,056.8
1996	630.6	19,750.0	75,805.9	8,005.9

Sources: U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summery*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures [Multiple Years]*. Washington, DC: Government Printing Office.

fiber boxes; fiber cans, drums, and similar products; sanitary food containers; building paper; packaging; bags; sanitary paper napkins; envelopes; stationary products; and other converted paper products.

4.4.1.3 Major By-Products and Co-Products

The paper and allied products industry is the largest user of industrial process water in the United States. In 1988, a typical mill used between 16,000 and 17,000 gallons of water per ton of paper produced. The equivalent amount of waste water discharged each day is about 16 million cubic meters (EPA, 1995b). Most facilities operate waste water treatment facilities on site to remove biological oxygen demand (BOD), total suspended solids (TSS), and other pollutants before discharging the water into a nearby waterway.

4.4.1.4 Costs of Production

Historical statistics for the costs of production for the paper and allied products industry are listed in Table 4-9. From 1987 to 1996, industry payroll generally ranged from approximately $19 to 20 billion. Employment peaked at 633,200 people in 1989 and declined slightly to 630,600 people by 1996. Materials costs averaged $74.4 billion a year and new capital investment averaged $8.3 billion a year.

4.4.1.5 Capacity Utilization

Table 4-10 presents the trend in capacity utilization for the paper and allied products industry. The varying capacities reflect adjusting production levels and new production facilities going on- or off-line. The average capacity utilization ratio for the paper and allied products industry between 1991 and 1996 was approximately 80, with capacity declining slightly in recent years.

Table 4-10. Capacity Utilization Ratios for the Paper and Allied Products Industry, 1991–1996

1991	1992	1993	1994	1995	1996
78	80	81	80	77	78

Note: All values are percentages.

Source: U.S. Department of Commerce, Bureau of the Census. 1998. *Survey of Plant Capacity: 1996.* Washington, DC: Government Printing Office.

4.4.2 Demand Side of the Industry

4.4.2.1 Product Characteristics

Paper is valued for its diversity in product types, applications, and low cost due to ready access to raw materials. Manufacturers produce papers of varying durabilities, textures, and colors. Consumers purchasing large quantities of papers may have papers tailored to their specification. Papers may be simple writing papers or newsprint for personal consumption and for the printing and publishing industry or durable for conversion into shipping cartons, drums, or sanitary boxes. Inputs in the paper production process are readily available in the United States because one-third of the country is forested, and facilities generally have ready access to waterways.

4.4.2.2 Uses and Consumers of Products

The paper and allied products industry is an integral part of the U.S. economy; nearly every industry and service sector relies on paper products for its personal, education, and business needs. Among a myriad of uses, papers are used for correspondence, printing and publishing, packing and storage, and sanitary purposes. Common applications are all manners of reading material, correspondence, sanitary containers, shipping cartons and drums, and miscellaneous packing materials.

4.4.3 Organization of the Industry

In 1992, 4,264 companies produced paper and allied products and operated 6,416 facilities. By way of comparison, 4,215 companies controlled 1,732 facilities in 1987. Although the number of small firms and facilities increased during those 5 years, the industry is dominated by high-volume, low-cost producers (Haltmaier, 1998). Even though they account for only 45 percent of all facilities, those with 50 or more employees contribute more than 93 percent of the industry's total value of shipments (see Table 4-11). (According to the Small Business Administration, those companies employing fewer than 500 employees are "small.")

For paper and allied products markets likely to be affected by the proposed boilers regulation, the CR4 ranged between 29 and 68 in 1992 (see Table 4-12). This means that, in each subsector, the top firms' combined sales ranged from 29 to 68 percent of their respective industry's total sales. For example,

Table 4-11. Size of Establishments and Value of Shipments for the Paper and Allied Products Industry (SIC 26/NAICS 322)

Number of Employees in Establishment	1987 Number of Facilities	1987 Value of Shipments ($\$10^6$)	1992 Number of Facilities	1992 Value of Shipments ($\$10^6$)
1 to 4 employees	729	640.6	786	216
4 to 9 employees	531	(D)	565	483
10 to 19 employees	888	1,563.4	816	1,456.5
20 to 49 employees	1,433	18,328.6	1,389	6,366.6
50 to 99 employees	1,018	(D)	1,088	12,811.5
100 to 249 employees	1,176	32,141.7	1,253	35,114.0
250 to 499 employees	308	24,221.1	298	22,281.2
500 to 999 employees	145	28,129.1	159	31,356.5
1,000 to 2,499 employees	63	24,903.1	62	23,115.4
2,500 or more employees	1	(D)		
Total	1,732	129,927.8	6,416	133,200.7

(D) = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1990c. *1987 Census of Manufactures, Industry Series: Pulp, Paper, and Board Mills*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Pulp, Paper, and Board Mills*. Washington, DC: Government Printing Office.

in the sanitary paper products industry, the CR4 ratios indicate that a few firms control 68 percent of the

Table 4-12. Measurements of Market Concentration for Paper and Allied Products Markets

SIC	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
2611	Pulp Mills	48	75	858	29	45
2621	Paper Mills	29	49	392	127	280
2676	Sanitary Paper Products	68	82	1,451	80	150

Sources: U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Pulp, Paper, and Board Mills*. Washington, DC: Government Printing Office.

market. This sector's moderately concentrated nature is also indicated by its HHI of 1,451 (DOJ, 1992). The remaining two sectors' HHIs indicate that their respective markets are unconcentrated (i.e., competitive).

4.4.4 Markets and Trends

The Department of Commerce projects that shipments of paper and allied products will increase through 2002 by an annual average of 2.5 percent (Haltmaier, 1998). Because nearly all of the industry's products are consumer related, shipments will be most affected by the health of the U.S. and global economy. The United States is a key competitor in the international market for paper products and, after Canada, is the largest exporter of paper products. According to Haltmaier (1998), the largest paper and allied products exporters in the world are Canada (with 23 percent of the market), the United States (10 to 15 percent), Finland (8 percent), and Sweden (7 percent).

4.5 Medicinal Chemicals and Botanical Products and Pharmaceutical Preparations (SICs 2833, 2834/NAICS 32451)

The pharmaceutical preparations industry (SIC 2834/NAICS 32451) and the medicinal chemicals and botanical products industry (SIC 2833/NAICS 32451) are both primarily engaged in the research, development, manufacture, and/or processing of medicinal chemicals and pharmaceutical products. Apart from manufacturing drugs for human and veterinary consumption, the industries grind, grade, and mill botanical products that are inputs for other industries. Typically, most facilities cross over into both industries (EPA, 1997a). Products include drugs, vitamins, herbal remedies, and production inputs, such as alkaloids and other active medicinal principals.

Table 4-13 presents both industries' value of shipments from 1987 to 1996. Medicinals and botanicals' performance during the late 1980s and early 1990s was mixed. However, shipments increased steadily from 1994 to 1996, increasing 37.7 percent as natural products such as herbs and vitamins became more popular (EPA, 1997a). Pharmaceutical preparations' shipments increased steadily over the 10-year period. From 1987 to 1996, the industry's shipments increased 24.3 percent to $55.1 billion in 1996.

Table 4-13. Value of Shipments for the Medicinals and Botanicals and Pharmaceutical Preparations Industries, 1987–1996

Year	SIC 2833 Medicinals & Botanicals ($\$10^6$)	SIC 2834 Pharmaceutical Preparations ($\$10^6$)
1987	4,629.1	44,345.7
1988	5,375.4	46,399.1
1989	5,708.9	48,083.6
1990	5,535.8	49,718.0
1991	6,637.7	49,866.3
1992	6,438.5	50,417.9
1993	5,669.2	50,973.5
1994	5,774.7	53,144.7
1995	6,404.1	53,225.9
1996	7,952.8	55,103.6

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures [Multiple Years]*. Washington, DC: Government Printing Office.

4.5.1 Supply Side of the Industry

4.5.1.1 Production Processes

The medicinals and botanical products industry and the pharmaceutical preparations industry share similar production processes. Many products of the former are inputs in the latter's production process. There are three manufacturing stages: research and development, preparation of bulk ingredients, and formulation of the final product.

The research and development stage is a long process both to ensure the validity and benefit of the end product and to satisfy the requirements of stringent federal regulatory committees. (The pharmaceutical industry operates under strict oversight of the Food and Drug Administration [FDA].) Therefore, every stage in the development of new drugs is thoroughly documented and studied. After a new compound is discovered, it is subjected to numerous laboratory and animal tests. Results are presented to the FDA via applications that present and fully disclose all findings to date. As research and development proceeds, studies are gradually expanded to involve human trials of the new compound. Should FDA approve the compound, the new product is readied for mass production.

To ensure a uniform product, all ingredients are prepared in bulk using batch processes. Companies produce enough of each ingredient to satisfy projected sales demand (EPA, 1997a). Prior to production, all equipment is thoroughly cleaned, prepared, and validated to prevent any contaminants from entering the production cycle. Most ingredients are prepared by chemical synthesis, a method whereby primary ingredients undergo a complex series of processes, including many intermediate stages and chemical reactions in a step-by-step fashion (EPA, 1997a).

After the bulk materials are prepared, they are converted into a final usable form. Common forms include tablets, pills, liquids, creams, and ointments. Equipment used in this final stage is prepared in the same manner as that involved in the bulk preparation process. Clean and validated machinery is used to process and package the pharmaceuticals for shipment and consumption.

4.5.1.2 Types of Output

Both industries produce pharmaceutical and botanical products for end consumption and intermediate products for the industries' own applications. Products include vitamins, herbal remedies, and alkaloids. Prescription and over-the-counter drugs are produced in liquid, tablet, cream, and other forms.

4.5.1.3 Major By-Products and Co-Products

Both industries produce many by-products because of the large number of primary inputs and the extensive chemical processes involved. Wastes and emissions vary by the process employed, raw materials consumed, and equipment used. In general, emissions originate during drying and heating stages and during process water discharge. Emissions controls are in place pursuant to environmental regulations. Other wastes include used filters, spent raw materials, rejected product, and reaction residues (EPA, 1997a).

4.5.1.4 Costs of Production

Table 4-14 presents SIC 2833 industry's costs of production and employment statistics from 1987 to 1996. Employment was stable during the late 1980s before steadily growing in the 1990s. In 1987, medicinals and botanicals employed 11,600 people. By 1996, the industry employed 16,800, an increase

Table 4-14. Inputs for Medicinal Chemicals and Botanical Products Industry (SIC 2833/NAICS 32451), 1987–1996

Year	Labor: Quantity (10^3)	Labor: Payroll ($\$10^6$)	Materials ($\$10^6$)	New Capital Investment ($\$10^6$)
1987	11.6	520.2	2,229.3	158.2
1988	11.3	494.4	2,658.8	194.9
1989	11.4	504.9	3,118.4	263.4
1990	10.9	476.4	2,902.4	218.9
1991	12.5	568.6	3,368.2	512.9
1992	13.0	587.1	3,245.9	550.5
1993	13.0	584.3	2,638.4	470.0
1994	13.9	572.6	2,755.2	480.3
1995	14.1	625.0	3,006.0	356.2
1996	16.8	752.1	3,793.9	752.1

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures, [Multiple Years]*. Washington, DC: Government Printing Office.

of nearly 45 percent. Materials costs matched the increase in shipments over this same period. Industry growth also fed new capital investments, which averaged $191.2 million a year in the late 1980s and $515.6 million a year in the early to mid-1990s.

SIC 2834's costs of production and employment for 1987 to 1996 are presented in Table 4-15. The number of people employed by the industry ranged between 123,000 and 144,000; employment peaked in 1990 before declining by 21,000 jobs by the end of 1992. During this 10-year period, the cost of materials rose 42.1 percent. The increase is associated with increased product shipments and the development of new, more expensive medications (Haltmaier, 1998). New capital investment averaged $2.3 billion a year.

4.5.1.5 Capacity Utilization

Table 4-16 presents the trend in these ratios from 1991 to 1996 for both industries. The varying capacity ratios reflect adjusting production volumes and new production facilities and capacity going both on- and off-line. In 1996, the capacity utilization ratios for SICs 2833 and 2834 were 84 and 67, respectively.

Table 4-15. Inputs for the Pharmaceutical Preparations Industry (SIC 2834/NAICS 32451), 1987-1996

Year	Labor: Quantity (10^3)	Labor: Payroll ($\$10^6$)	Materials ($\$10^6$)	New Capital Investment ($\$10^6$)
1987	131.6	5,759.2	11,693.7	2,032.7
1988	133.4	5,447.2	12,634.8	2,234.0
1989	141.8	6,177.5	12,874.2	2,321.4
1990	143.8	6,223.9	13,237.6	2,035.3
1991	129.1	5,275.8	13,546.6	1,864.7
1992	122.8	4,949.4	13,542.5	2,450.0
1993	128.2	5,184.2	13,508.7	2,385.2
1994	134.2	5,368.4	13,526.1	2,531.9
1995	143.0	5,712.4	15,333.6	2,856.1
1996	136.9	5,547.3	16,611.1	2,317.0

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures, [Multiple Years]*. Washington, DC: Government Printing Office.

Table 4-16. Capacity Utilization Ratios for the Medicinal Chemicals and Botanical Products (SIC 2833/NAICS 32451) and Pharmaceutical Preparations (SIC 2834/NAICS 32451) Industries, 1991-1996

	1991	**1992**	**1993**	**1994**	**1995**	**1996**
SIC 2833/NAICS 32451	84	86	89	80	90	84
SIC 2834/NAICS 32451	76	74	70	67	63	67

Note: Capacity utilization ratio is the ratio of the actual production level to the full production level. All values are percentages.

Source: U.S. Department of Commerce, Bureau of the Census. 1998. *Survey of Plant Capacity: 1996*. Washington, DC: Government Printing Office.

4.5.2 Demand Side of the Industry

New product introductions and improvements on older medications by the drug industry have greatly improved the health and well-being of the U.S. population (Haltmaier, 1998). Products help alleviate or reduce physical, mental, and emotional ailments or reduce the severity of symptoms associated with disease, age, and degenerative conditions. Dietary supplements, such as vitamins and herbal remedies, ensure that consumers receive nutrients of which they may not ordinarily consume enough. Products are available in a range of dosage types, such as tablets and liquids.

Although prescription medications are increasingly distributed through third parties, such as hospitals and health maintenance organizations, the general population remains the end user of pharmaceutical products. As the average age of the U.S. population adjusts to reflect large numbers of older people, the variety and number of drugs consumed increases. An older population will generally consume more medications to maintain and improve quality of life (Haltmaier, 1998).

4.5.3 Organization of the Industry

In 1992, 208 companies produced medicinal chemicals and botanical products and operated 225 facilities (see Table 4-17). The number of companies and facilities in 1992 was the same as that of 1987, although shipment values increased almost 40 percent. The average facility employed more people in 1992 than in 1987. In fact, the number of facilities employing 50 or more people grew from 37 to 45. These facilities accounted for the lion's share of the industry's shipments. According to the Small Business Administration, companies in this SIC code are considered small if they employ fewer than 750 employees. It is unclear what percentage of the facilities listed in Table 4-17 are small companies.

In 1992, 585 companies manufactured pharmaceutical preparations and operated 691 facilities. By way of comparison, 640 companies operated 732 facilities in 1987. Although the number of facilities

Table 4-17. Size of Establishments and Value of Shipments for the Medicinal Chemicals and Botanical Products (SIC 2833/NAICS 32451) and Pharmaceutical Preparations (SIC 2834/NAICS 32451) Industries

Number of Employees in Establishment	1987 Number of Facilities	1987 Value of Shipments ($\$10^6$)	1992 Number of Facilities	1992 Value of Shipments ($\$10^6$)
SIC 2833/NAICS 32451				
1 to 4 employees	61	20.7	62	23.8
5 to 9 employees	34	38.6	42	58.3
10 to 19 employees	46	237.0	47	357.1
20 to 49 employees	47	287.3	29	182.0
50 to 99 employees	15	273.6	25	653.9
100 to 249 employees	12	520.6	10	5,163.4
250 to 499 employees	5	753.0	4	(D)
500 to 999 employees	4	2478.2	3	(D)
1,000 to 2,499 employees	1	(D)	3	(D)
Total	225	4629.1	225	6,438.5
SIC 2834/NAICS 32451				
1 to 4 employees	158	58.7	152	115.6
5 to 9 employees	108	178.8	73	105.4
10 to 19 employees	102	320.3	101	284.6
20 to 49 employees	117	932.5	110	815.7
50 to 99 employees	66	1231.0	65	1,966.8
100 to 249 employees	76	3596.0	77	2,912.4
250 to 499 employees	50	9239.7	56	11,394.6
500 to 999 employees	23	4946.9	30	10,077.7
1,000 to 2,499 employees	24	15,100.9	21	14,525.7
2,500 employees or more	8	8740.9	6	8,219.4
Total	732	44,345.7	691	50,417.9

(D) = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1990a. *1987 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of*

with more than 50 employees accounted for at least 95 percent of the industry's shipments.

Table 4-18 presents the measures of market concentration for both industries. For the medicinals and botanicals industry, the CR4 was 76 in 1992, and the CR8 was 84 (U.S. Department of Commerce, 1995b). The highly concentrated nature of the market is further indicated by an HHI of 2,999 (DOJ, 1992). According to the Department of Justice's Horizontal Merger Guidelines, industries with HHIs above 1,800 are less competitive.

Table 4-18. Measures of Market Concentration for the Medicinal Chemicals and Botanical Products (SIC 2833/NAICS 32451) and Pharmaceutical Preparations (SIC 2834/NAICS 32451) Industries

SIC	NAICS	Industry	CR4	CR8	HHI	Number of Companies	Number of Facilities
2833	32451	Medicinal Chemicals and Botanical Products	76	84	2,999	208	225
2834	32451	Pharmaceutical Preparations	26	42	341	585	691

Sources: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.

The pharmaceuticals preparations industry is less concentrated than the medicinal chemicals and botanical products industry. For SIC 2834, the CR4 and CR8 were 26 and 42, respectively, in 1992. The industry's HHI was 341, indicating a competitive market.

4.5.4 Markets and Trends

According to the Department of Commerce, global growth in the consumption of pharmaceuticals is projected to accelerate over the coming decade as populations in developed countries age and those in developing nations gain wider access to health care. Currently, the United States remains the largest market for drugs, medicinals, and botanicals and produces more new products than any other country (Haltmaier, 1998). But, nearly two-fifths of American producers' sales are generated abroad. Top markets for American exports are China, Canada, Mexico, Australia, and Japan. Most imports originate in Canada, Russia, Mexico, Trinidad and Tobago, and Norway.

4.6 Industrial Organic Chemicals Industry (SIC 2869/NAICS 3251)

The industrial organic chemicals (not elsewhere classified) industry (SIC 2869/NAICS 3251) produces organic chemicals for end-use applications and for inputs into numerous other chemical manufacturing industries. In nominal terms, it was the single largest segment of the $367 billion chemical and allied products industry (SIC 28) in 1996, accounting for approximately 17 percent of the industry's shipments.

All organic chemicals are, by definition, carbon-based and are divided into two general categories: commodity and specialty. Commodity chemical manufacturers compete on price and produce large volumes of staple chemicals using continuous manufacturing processes. Specialty chemicals cater to custom markets, using batch processes to produce a diverse range of chemicals. Specialty chemicals generally require more technical expertise and research and development than the more standardized commodity chemicals industry (EPA, 1995c). Consequently, specialty chemical manufacturers have a greater value added to their products. End products for all industrial organic chemical producers are as varied as synthetic perfumes, flavoring chemicals, glycerin, and plasticizers.

Table 4-19 presents the shipments of industrial organic chemicals from 1987 to 1996. In real terms, the industry's shipments rose in the late 1980s to a high of $54.9 billion before declining in the early 1990s as the U.S. economy went into recession. By the mid-1990s, the industry recovered, as product values reached record highs (Haltmaier, 1998). Between 1993 and 1996, the industry's shipments grew 7.3 percent to $57.7 billion.

Table 4-19. Value of Shipments for the Industrial Organic Chemicals, N.E.C. Industry (SIC 2869/NAICS 3251), 1987-1996

Year	Value of Shipments (1992 $\$10^6$)
1987	48,581.7
1988	53,434.7
1989	54,962.9
1990	53,238.8
1991	51,795.6
1992	54,254.2
1993	53,805.2
1994	57,357.1
1995	59,484.3
1996	57,743.3

Sources: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures, Multiple Years*. Washington, DC: Government Printing Office.

4.6.1 Supply Side of the Industry

4.6.1.1 Production Processes

Processes used to manufacture industrial organic chemicals are as varied as the end-products themselves. There are thousands of possible ingredients and hundreds of processes. Therefore, the discussion that follows is a general description of the ingredients and stages involved in a typical manufacturing process.

Essentially a set of ingredients (feedstocks) is combined in a series of reactions to produce end products and intermediates (EPA, 1995c). The typical chemical synthesis processes incorporate multiple feedstocks in a series of chemical reactions. Commodity chemicals are produced in a continuous reactor, and specialty chemicals are produced in batches. Specialty chemicals may undergo a series of reaction steps, as opposed to commodity chemicals' one continuous reaction because a finite amount of ingredients are prepared and used in the production process. Reactions usually take place at high temperatures, with one or two additional components being intermittently added. As the production advances, by-products are removed using separation, distillation, or refrigeration techniques. The final product may undergo a drying or pelletizing stage to form a more manageable substance.

4.6.1.2 Types of Output

Miscellaneous industrial organic chemicals comprise nine general categories of products:

- aliphitic and other acyclic organic chemicals (ethylene); acetic, chloroaceptic, adipic, formic, oxalic, and tartaric acids and their metallic salts; chloral, formaldehyde, and methylamine;
- solvents (ethyl alcohol etc.); methanol; amyl, butyl, and ethyl acetates; ethers; acetone, carbon disulfide and chlorinated solvents;
- polyhydric alcohols (synthetic glycerin, etc.);
- synthetic perfume and flavoring materials (citral, methyl, oinone, etc.);
- rubber processing chemicals, both accelerators and antioxidants (cyclic and acyclic);
- cyclic and acyclic plasticizers (phosphoric acid, etc.);
- synthetic tanning agents;
- chemical warfare gases; and
- esters, amines, etc., of polyhydric alcohols and fatty and other acids.

4.6.1.3 Major By-Products and Co-Products

Co-products, by-products, and emissions vary according to the ingredients, processes, maintenance practices, and equipment used (EPA, 1997b). Frequently, residuals from the reaction process that are separated from the end product are resold or possibly reused in the manufacturing process. A by-product from one process may be another's input. The industry is strictly regulated because it emits chemicals through many types of media, including discharges to air, land, and water, and because of the volume and composition of these emissions.

4.6.1.4 Costs of Production

Of all the factors of production, employment in industrial organic chemicals fluctuated most often between 1987 and 1996 (see Table 4-20). During that time, employment fell 8.18 percent to 92,100, after a high of 101,000 in 1991. Most jobs lost were at the production level (Haltmaier, 1998). Facilities became far more computerized, incorporating advanced technologies into the production process. Even with the drop in employment, payroll was $200 million more in 1995 than in 1987. The cost of materials fluctuated between $29 and $36 billion for these years, and new capital investment averaged $3,646 million a year.

Table 4-20. Inputs for the Industrial Organic Chemicals Industry (SIC 2869/NAICS 3251), 1987–1996

	Labor			
Year	Quantity (10^3)	Payroll (1992 $\$10^6$)	Materials (1992 $\$10^6$)	New Capital Investment (1992 $\$10^6$)
1987	100.3	4,295.8	28,147.7	2,307.4
1988	97.1	4,045.1	29,492.8	2,996.5
1989	97.9	3,977.4	29,676.4	3,513.0
1990	100.3	4,144.6	29,579.2	4,085.5
1991	101.0	4,297.3	29,335.2	4,428.7
1992	100.1	4,504.2	31,860.6	4,216.6
1993	97.8	4,540.2	30,920.1	3,386.1
1994	89.8	4,476.5	33,267.4	2,942.8
1995	92.1	4,510.4	33,163.9	3,791.0
1996	100.3	5,144.8	36,068.9	4,794.7

Sources: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures*. Washington, DC: Government Printing Office.

4.6.1.5 Capacity Utilization

Table 4-21 presents the trend in capacity utilization ratios from 1991 to 1996 for the industrial organic chemicals industry. The varying capacity utilization ratios reflect changes in production volumes and new production facilities and capacities going on- and off-line. The capacity utilization ratio for the industry averaged 85.3 over the 6-year period presented.

4.6.2 Demand Side of the Industry

Industrial organic chemicals are components of many chemical products. Most of the chemical sectors (classified under SIC 28) are downstream users of organic chemicals. These sectors either purchase commodity chemicals or enter into contracts with industrial organic chemical producers to obtain specialty chemicals. Consumers include inorganic chemicals (SIC 281), plastics and synthetics (SIC 282), drugs (283), soaps and cleaners (SIC 284), paints and allied products (SIC 286), and miscellaneous chemical products (SIC 289).

Table 4-21. Capacity Utilization Ratios for the Industrial Organic Chemicals Industry (SIC 2869/NAICS 3251), 1991–1996

	1991	1992	1993	1994	1995	1996
SIC 2869/NAICS 3251	86	81	91	89	84	84

Note: The capacity utilization ratio is the ratio of the actual production level to the full production level.

All values are percentages.

Source: U.S. Department of Commerce, Bureau of the Census. 1998. *Survey of Plant Capacity: 1996.* Washington, DC: Government Printing Office.

4.6.3 Organization of the Industry

Although the industry's value of shipments increased nearly 12 percent between 1987 and 1992, the number of facilities producing industrial organic chemicals only increased by 6 percent. Facilities with 100 or more employees continued to account for the majority of the industry's shipment values. For example, in 1992, 28 percent of all facilities had 100 or more employees (see Table 4-22), and these facilities produced 89 percent of the industry's shipment values. The average number of facilities per firm was 1.4 in both years. According to the Small Business Administration, an industrial organic chemicals company is considered small if the total number of employees does not exceed 500. It is unclear what percentage of facilities are owned by small businesses.

The industrial organic chemicals (not elsewhere classified) industry is unconcentrated and competitive. The CR4 was 29 and the CR8 43; the industry's HHI was 336.

4.6.4 Markets and Trends

The U.S. industrial organic chemical industry is expected to expand through 2002 at an annual rate of 1.4 percent (Haltmaier, 1998). U.S. producers face increasing competition domestically and abroad as chemical industries in developing nations gain market share and increase exports to the United States. American producers will, however, benefit from decreasing costs for raw materials and energy and productivity gains.

Table 4-22. Size of Establishments and Value of Shipments for the Industrial Organic Chemicals Industry (SIC 2869/NAICS 3251)

Number of Employees in Establishment	1987 Number of Facilities	1987 Value of Shipments (1992 $\$10^6$)	1992 Number of Facilities	1992 Value of Shipments (1992 $\$10^6$)
1 to 4 employees	97	552.8	100	102.6
5 to 9 employees	80	200.9	80	208.7
10 to 19 employees	91	484.7	97	533.9
20 to 49 employees	137	1,749.9	125	1,701.5
50 to 99 employees	99	2556.3	106	3,460.9
100 to 249 employees	110	10,361.2	111	8,855.9
250 to 499 employees	41	17,156.9	41	9,971.1
500 to 999 employees	27	9,615.5	30	13,755.0
1,000 to 2,499 employees	11	9,184.6	10	9,051.0
2,500 or more employees	6	7,156.9	5	6,613.5

Sources: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1990b. *1987 Census of Manufactures, Industry Series, Paints and Allied Products*. Washington, DC: Government Printing Office.

4.7 Electric Services (SIC 4911/NAICS 22111)

The ongoing process of deregulation of wholesale and retail electric markets is changing the structure of the electric power industry. Deregulation is leading to the functional unbundling of generation, transmission, and distribution and to competition in the generation segment of the industry. This profile provides background information on the U.S. electric power industry and discusses current industry characteristics and trends that will influence the future generation and consumption of electricity. It is important to note that through out this report the terms “boilers,” “process heaters,” and “units” are synonymous with “ICI boilers” and “process heaters.” Boilers primarily engaged in the generation of electricity are not covered by the NESHAP under analysis and are therefore excluded from this analysis. Utility sources are not affected by this NESHAP except for a small number of nonfossil fuel units within this industry. Those units in this industry that are affected may be engaged in activities such as heating and mechanized work.

4.7.1 Electricity Production

Figure 4-1 illustrates the typical structure of the electric utility market. Even with the technological and regulatory changes in the 1970s and 1980s, at the beginning of the 1990s the structure of the electric utility industry could still be characterized in terms of generation, transmission, and distribution. Commercial and retail customers were in essence “captive,” and rates and service quality were primarily determined by public utility commissions.

The majority of utilities are interconnected and belong to a regional power pool. Pooling arrangements enable facilities to coordinate the economic dispatch of generation facilities and manage transmission congestion. In addition, pooling diverse loads can increase load factors and decrease costs by sharing reserve capacity.

4.7.1.1 Generation

As shown in Table 4-23, coal-fired plants have historically accounted for the bulk of electricity generation in the United States. With abundant national coal reserves and advances in pollution abatement technology, such as advanced scrubbers for pulverized coal and flue gas-desulfurization systems, coal will likely remain the fuel of choice for most existing generating facilities over the near term.

Natural gas accounts for approximately 10 percent of current generation capacity but is expected to grow; advances in natural gas exploration and extraction technologies and new coal gasification have contributed to the use of natural gas for power generation.

Nuclear plants and renewable energy sources (e.g., hydroelectric, solar, wind) provide approximately 20 percent and 10 percent of current generating capacity, respectively. However, there are no plans for new nuclear facilities to be constructed, and there is little additional growth forecasted in renewable energy.

Table 4-23. Net Generation by Energy Source, 1995

Energy Source	Utility Generators (MWh)	Nonutility Generators (MWh)	Total (MWh)
Fossil fuels	2,021,064	287,696	2,308,760
Coal	1,652,914	63,440	
Natural gas	307,306	213,437	
Petroleum	60,844	3,957	
Nuclear	673,402	—	673,402
Hydroelectric	293,653	14,515	308,168
Renewable/other	6,409	98,295	104,704
Total	2,994,582	400,505	3,395,033

Sources: U.S. Department of Energy, Energy Information Administration. 1996. *Electric Power Annual, 1995*. Vol. 1. DOE/EIA-0348(95/1). Washington, DC: U.S. Department of Energy.

U.S. Department of Energy, Energy Information Administration. 1999b. *The Changing Structure of the Electric Power Industry 1999: Mergers and Other Corporate Combinations*. Washington, DC: U.S. Department of Energy.

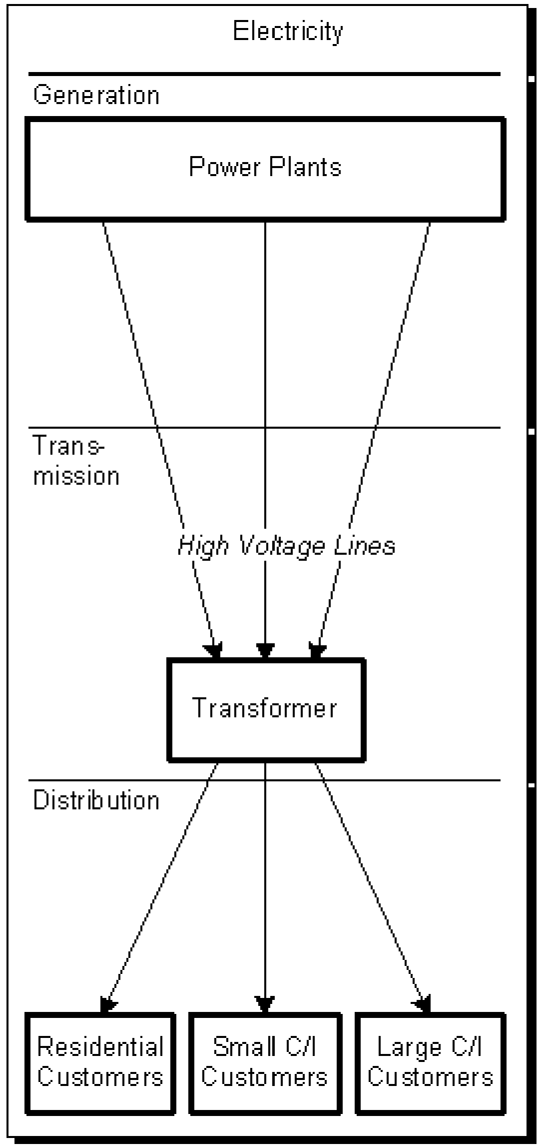


Figure 4-1. Traditional Electric Power Industry Structure

4.7.1.2 Transmission

Transmission refers to high voltage lines used to link generators to substations where power is stepped down for local distribution. Transmission systems have been traditionally characterized as a collection of independently operated networks or grids interconnected by bulk transmission interfaces.

Within a well-defined service territory, the regulated utility has historically had responsibility for all aspects of developing, maintaining, and operating transmissions. These responsibilities included

- system planning and expanding,
- maintaining power quality and stability, and
- responding to failures.

Isolated systems were connected primarily to increase (and lower the cost of) power reliability. Most utilities maintained sufficient generating capacity to meet customer needs, and bulk transactions were initially used only to support extreme demands or equipment outages.

4.7.1.3 Distribution

Low-voltage distribution systems that deliver electricity to customers comprise integrated networks of smaller wires and substations that take the higher voltage and step it down to lower levels to match customers' needs.

The distribution system is the classic example of a natural monopoly because it is not practical to have more than one set of lines running through neighborhoods or from the curb to the house.

4.7.2 Cost of Production

Table 4-24 shows total industry expenditures by production activities. Generation accounts for approximately 75.6 percent of the cost of delivered electric power in 1996. Transmission and distribution accounted for 2.5 percent and 5.6 percent, respectively. Customer accounts and sales and administrative costs accounted for the remaining 16.3 percent of the cost of delivered power.

4.7.3 Organization of the Industry

Because the restructuring plans and time tables are made at the state level, the issues of asset ownership and control throughout the current supply chain in the electric power industry vary from state to state. However, the activities conducted throughout the supply chain are generally the same. This section focuses on the generation segment of the market because all the boilers affected by the regulation are involved in generation.

As part of deregulation, the transmission and distribution of electricity are being separated from the business of generating electricity, and a new competitive market in electricity generation is evolving. As power generators prepare for the competitive market, the share of electricity generation attributed to nonutilities and utilities is shifting.

More than 7,000 electricity suppliers currently operate in the U.S. market. As shown in Table 4-25, approximately 42 percent of suppliers are utilities and 58 percent are nonutilities. Utilities include investor-owned, cooperatives, and municipal systems. Of the approximately 3,100

Table 4-24. Total Expenditures in 1996 ($\$10^3$)

Utility Ownership	Generation	Transmission	Distributio n	Customer Accounts and Sales	Administration and General Expenses
Investor-owned	80,891,644	2,216,113	6,124,443	6,204,229	13,820,059
Publicly owned	12,495,324	840,931	1,017,646	486,195	1,360,111
Federal	3,685,719	327,443	1,435	55,536	443,809
Cooperatives	15,105,404	338,625	1,133,984	564,887	1,257,015
	112,178,091	3,723,112	8,277,508	7,310,847	16,880,994
	75.6%	2.5%	5.6%	4.9%	11.4%
	148,370,552				

Sources: U.S. Department of Energy, Energy Information Administration (EIA). 1998b. *Financial Statistics of Major Publicly Owned Electric Utilities, 1997*. Washington, DC: U.S. Department of Energy.

U.S. Department of Energy, Energy Information Administration (EIA). 1997. *Financial Statistics of Major U.S. Investor-Owned Electric Utilities, 1996*. Washington, DC: U.S. Department of Energy.

utilities operating in the United States, only about 700 generate electric power. The majority of utilities distribute electricity that they have purchased from power generators via their own distribution systems.

Utility and nonutility generators produced a total of 3,369 billion kWh in 1995. Although utilities generate the vast majority of electricity produced in the United States, nonutility generators are quickly eroding utilities' shares of the market. Nonutility generators include private entities that generate power for their own use or to sell to utilities or other end users. Between 1985 and 1995, nonutility generation increased from 98 billion kWh (3.8 percent of total generation) to 374 billion kWh (11.1 percent). Figure 4-2 illustrates this shift in the share of utility and nonutility generation.

4.7.3.1 Utilities

There are four categories of utilities: investor-owned utilities (IOUs), publicly owned utilities, cooperative utilities, and federal utilities. Of the four, only IOUs always generate electricity.

IOUs are increasingly selling off generation assets to nonutilities or converting those assets into nonutilities (Haltmaier, 1998). To prepare for the competitive market, IOUs have been lowering their operating costs, merging, and diversifying into nonutility businesses.

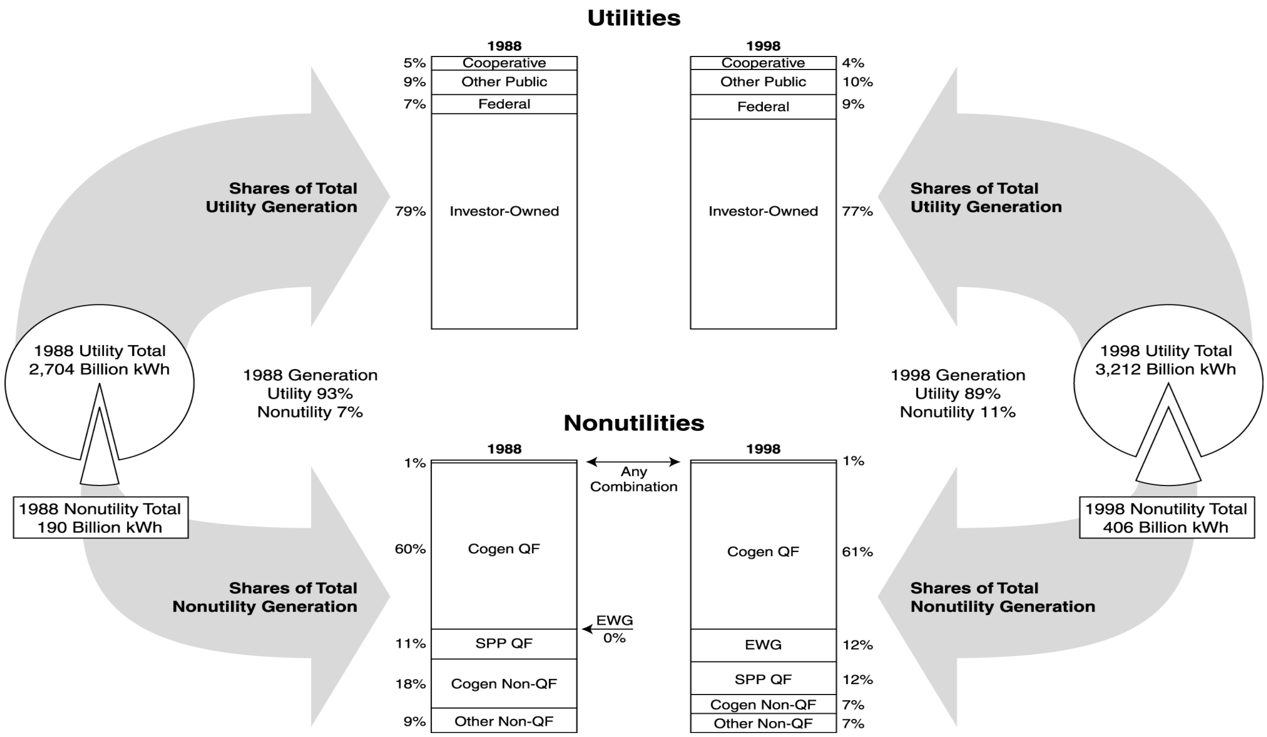
In 1995, utilities generated 89 percent of electricity, a decrease from 96 percent in 1985. IOUs generate the majority of the electricity produced in the United States. IOUs are either individual corporations or a holding company, in which a parent company operates one or more utilities integrated with one another. IOUs account for approximately three-quarters of utility generation, a percentage that held constant between 1985 and 1995.

Many states, municipalities, and other government organizations also own and operate utilities, although the majority do not generate electricity. Those that do generate electricity operate capacity to supply some or all of their customers' needs. They tend to be small, localized outfits and can be found in 47 states. These publicly owned utilities accounted for about one-tenth of utility generation in 1985 and 1995. In a deregulated market, these generators may be in direct competition with other utilities to service their market.

Table 4-25. Number of Electricity Suppliers in 1999

Electricity Suppliers	Number	Percent
Utilities	3,124	42%
Investor-owned utilities	222	
Cooperatives	875	
Municipal systems	1,885	
Public power districts	73	
State projects	55	
Federal agencies	14	
Nonutilities	4,247	58%
Nonutilities (excluding EWGs)	4,103	
Exempt wholesale generators	144	
Total	7,371	100%

Source: U.S. Department of Energy, Energy Information Administration (EIA). 1999b. *The Changing Structure of the Electric Power Industry 1999: Mergers and Other Corporate Combinations*. Washington, DC: U.S. Department of Energy.



[a] Includes facilities classified in more than one of the following FERC designated categories: cogenerator QF, small power producer QF, or exempt wholesale generator.
Cogen = Cogenerator.

EWG = Exempt wholesale generator.

Other Non-QF = Nocogenerator Non-QF.

QF = Qualifying facility.

SPP = Small power producer.

Note: Sum of components may not equal total due to independent rounding. Classes for nonutility generation are determined by the class of each generating unit.

Sources: **Utility data:** U.S. Department of Energy, Energy Information Administration (EIA). 1996. *Electric Power Annual 1995*. Volumes I and II. DOE/EIA-0348(95)/1. Washington, DC: U.S. Department of Energy; Table 8 (and previous issues); **1985 nonutility data:** Shares of generation estimated by EIA; total generation from Edison Electric Institute (EEI). 1998. *Statistical Yearbook of the Electric Utility Industry 1998*. November. Washington, DC; **1995 nonutility data:** U.S. Department of Energy, Energy Information Administration (EIA). 1996. *Electric Power Annual 1995.* Volumes I and II. DOE/EIA-0348(95)/1. Washington, DC: U.S. Department of Energy.

Figure 4-2. Utility and Nonutility Generation and Shares by Class, 1988 and 1998

Rural electric cooperatives are formed and owned by groups of residents in rural areas to supply power to those areas. Cooperatives generally purchase from other utilities the energy that they sell to customers, but some generate their own power. Cooperatives only produced 5 percent of utility generation in 1985 and only 6 percent in 1995.

Utilities owned by the federal government accounted for about one-tenth of generation in both 1985 and 1995. The federal government operated a small number of large utilities in 1995 that supplied power to large industrial consumers or federal installations. The Tennessee Valley Authority is an example of a federal utility.

4.7.3.2 Nonutilities

Nonutilities are private entities that generate power for their own use or to sell to utilities or other establishments. Nonutilities are usually operated at mines and manufacturing facilities, such as chemical plants and paper mills, or are operated by electric and gas service companies (DOE, EIA, 1998a). More than 4,200 nonutilities operate in the United States.

4.7.4 Demand Side of the Industry

4.7.4.1 Electricity Consumption

This section analyzes the growth projections for electricity consumption as well as the price elasticity of demand for electricity. Growth in electricity consumption has traditionally paralleled gross domestic product growth. However, improved energy efficiency of electrical equipment, such as high-efficiency motors, has slowed demand growth over the past few decades. The magnitude of the relationship has been decreasing over time, from growth of 7 percent per year in the 1960s down to 1 percent in the 1980s. As a result, determining what the future growth will be is difficult, although it is expected to be positive (DOE, EIA, 1999a). Table 4-26 shows consumption by sector of the economy over the past 10 years. The table shows that since 1989 electricity sales have increased at least 10 percent in all four sectors. The commercial sector has experienced the largest increase, followed by residential consumption.

In the future, residential demand is expected to be at the forefront of increased electricity consumption. Between 1997 and 2020, residential demand is expected to increase at 1.6 percent annually. Commercial growth in demand is expected to be approximately 1.4 percent, while

Table 4-26. U.S. Electric Utility Retail Sales of Electricity by Sector, 1989 Through 1998 (10^6 kWh)

Period	Residential	Commercial	Industrial	Other[a]	All Sectors
1989	905,525	725,861	925,659	89,765	2,646,809
1990	924,019	751,027	945,522	91,988	2,712,555
1991	955,417	765,664	946,583	94,339	2,762,003
1992	935,939	761,271	972,714	93,442	2,763,365
1993	994,781	794,573	977,164	94,944	2,861,462
1994	1,008,482	820,269	1,007,981	97,830	2,934,563
1995	1,042,501	862,685	1,012,693	95,407	3,013,287
1996	1,082,491	887,425	1,030,356	97,539	3,097,810
1997	1,075,767	928,440	1,032,653	102,901	3,139,761
1998	1,124,004	948,904	1,047,346	99,868	3,220,121
Percentage change 1989-1998	19%	24%	12%	10%	18%

[a] Includes public street and highway lighting, other sales to public authorities, sales to railroads and railways, and interdepartmental sales.

Sources: U.S. Department of Energy, Energy Information Administration (EIA). 1999d. *Electric Power Annual 1998*. Volumes I and II. Washington, DC: U.S. Department of Energy.

U.S. Department of Energy, Energy Information Administration (EIA). 1996. *Electric Power Annual 1995*. Volumes I and II. Washington, DC: U.S. Department of Energy.

industry is expected to increase demand by 1.1 percent (DOE, EIA, 1999a). Figure 4-3 shows the annual electricity sales by sector from 1970 with projections through 2020.

The literature suggests that electricity consumption is relatively price inelastic. Consumers are generally unable or unwilling to forego a large amount of consumption as the price increases. Numerous studies have investigated the short-run elasticity of demand for electricity. Overall, the studies suggest that, for a 1 percent increase in the price of electricity, demand will decrease by 0.15 percent. However, as Table 4-27 shows, elasticities vary greatly, depending on the demand characteristics of end users and the price structure. Demand elasticities are estimated to range from a –0.05 percent elasticity of demand for a "flat rates" case (i.e., no time-of-use assumption) up to a –0.50 percent demand elasticity for a "high consumer response" case (DOE, EIA, 1999c).

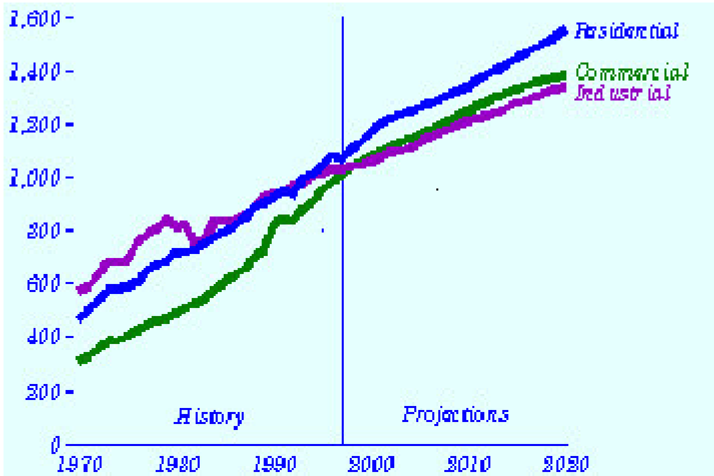


Figure 4-3. Annual Electricity Sales by Sector

4.7.4.2 Trends in the Electricity Market

Beginning in the latter part of the 19th century and continuing for about 100 years, the prevailing view of policymakers and the public was that the government should use its power to require or prescribe the economic behavior of "natural monopolies" such as electric utilities. The traditional argument is that it does not make economic sense for there to be more than one supplier—running two sets of wires from generating facilities to end users is more costly than one set. However, since monopoly supply is not generally regarded as likely to provide a socially optimal allocation of resources, regulation of rates and other economic variables was seen as a necessary feature of the system.

Beginning in the 1970s, the public policy view shifted against traditional regulatory approaches and in favor of deregulation for many important industries including transportation, communications, finance, and energy. The major drivers for deregulation of electric power included the following:

- existence of rate differentials across regions offering the promise of benefits from more efficient use of existing generation resources if the power can be transmitted across larger geographic areas than was typical in the era of industry regulation;

the erosion of economies of scale in generation with advances in combustion turbine technology;

- complexity of providing a regulated industry with the incentives to make socially efficient investment choices;
- difficulty of providing a responsive regulatory process that can quickly adjust rates and conditions of service in response to changing technological and market conditions; and
- complexity of monitoring utilities' cost of service and establishing cost-based rates for various customer classes that promote economic efficiency while at the same time addressing equity concerns of regulatory commissions.

Viewed from one perspective, not much changes in the electric industry with restructuring. The same functions are being performed, essentially the same resources are being used, and in a broad sense the same reliability criteria are being met. In other ways, the very nature of restructuring, the harnessing of competitive forces to perform a previously regulated function, changes almost everything. Each provider and each function become separate competitive entities that must be judged on their own.

This move to market-based provision of generation services is not matched on the transmission and distribution side. Network interactions on AC transmission systems have made it impossible to have separate transmission paths compete. Hence, transmission and distribution remain regulated.

Transmission and generation heavily interact, however, and transmission congestion can prevent specific generation from getting to market. Transmission expansion planning becomes an open process with many interested parties. This open process, coupled with frequent public opposition to transmission expansion, slows transmission enhancement. The net result is greatly increased pressure on the transmission system.

Table 4-27. Key Parameters in the Cases

Case Name	Key Assumptions: Cost Reduction and Efficiency Improvements	Short-Run Elasticity of Demand (Percent)	Natural Gas Prices	Capacity Additions
AEO97 Reference Case	AEO97 Reference Case	—	AEO97 Reference Case	As needed to meet demand
No Competition	No change from 1995	—	AEO97 Reference Case	As needed to meet demand
Flat Rates (no time-of-use rates)	AEO97 Reference Case	–0.05	AEO97 Reference Case	As needed to meet demand
Moderate Consumer Response	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand
High Consumer Response	AEO97 Reference Case	–0.50	AEO97 Reference Case	As needed to meet demand
High Efficiency	Increased cost savings and efficiencies	–0.15	AEO97 Reference Case	As needed to meet demand
No Capacity Additions	AEO97 Reference Case	–0.15	AEO97 Low Oil and Gas Supply Technology Case	Not allowed
High Gas Price	AEO97 Reference Case	–0.15	AEO97 High Oil and Gas Supply Technology Case	As needed to meet demand
Low Gas Price	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand
High Value of Reliability	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand
Half O&M	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand
Intense Competition	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand

Restructuring of the electric power industry could result in any one of several possible market structures. In fact, different parts of the country will probably use different structures, as the current trend indicates. The eventual structure may be dominated by a power exchange, bilateral contracts, or a combination. A strong Regional Transmission Organization (RTO) may operate in the area, or a vertically integrated utility may continue to operate a control area. In any case, several important characteristics will change:

- Commercial provision of generation-based services (e.g., energy, regulation, load following, voltage control, contingency reserves, backup supply) will replace regulated service provision. This drastically changes how the service provider is assessed.
- Individual transactions will replace aggregated supply meeting aggregated demand. It will be necessary to continuously assess each individual's performance.
- Transaction sizes will shrink. Instead of dealing only in hundreds and thousands of MW, it will be necessary to accommodate transactions of a few MW and less.
- Supply flexibility will greatly increase. Instead of services coming from a fixed fleet of generators, service provision will change dynamically among many potential suppliers as market conditions change.

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CHAPTER 5
ECONOMIC ANALYSIS METHODOLOGY

The rule to control emissions of HAPs from industrial, commercial, and institutional boilers and process heaters will affect almost all sectors of the U.S. economy. Several markets will bear the direct compliance costs. In addition, sectors that consume energy will also bear indirect costs through higher prices for energy. Finally, consumers of goods and services will experience impacts from higher market prices.

This chapter presents the methodology for analyzing the economic impacts of the NESHAP. This economic analysis provides the economic data and supporting information needed by EPA to support its regulatory determination. The methodology to operationalize this theory is based on microeconomic theory and the methods developed for earlier EPA studies. These methods are tailored to and extended for this analysis, as appropriate, to meet EPA's requirements for an EIA of controls placed on boilers and process heaters.

This methodology chapter includes background information on typical economic modeling approaches, the conceptual approach selected for this EIA, and an overview of the computerized market model used in the analysis with emphasis on the links between energy markets and the markets for goods and services. Appendix A of this RIA includes a description of the model's baseline data set and specifications.

5.1 Background on Economic Modeling Approaches

In general, the EIA methodology needs to allow EPA to consider the effects of the different regulatory alternatives. Several types of economic impact modeling approaches have been developed to support regulatory development. These approaches can be viewed as varying along two modeling dimensions:

- the scope of economic decisionmaking accounted for in the model and
- the scope of interaction between different segments of the economy.

Each of these dimensions was considered in determining the approach for this study. The advantages and disadvantages of different modeling approaches are discussed below.

5.1.1 Modeling Dimension 1: Scope of Economic Decisionmaking

Models incorporating different levels of economic decisionmaking can generally be categorized as *with* behavior responses and *without* behavior responses (accounting approach). Table 5-1 provides a brief comparison of the two approaches. The nonbehavioral approach essentially holds fixed all interactions between facility production and market forces. It assumes that firms absorb all control costs and consumers do not face any of the costs of regulation. Typically, engineering control costs are weighted by the number of affected units to develop "engineering" estimates of the total annualized costs. These costs are then compared to company or industry sales to determine the regulation's impact.

Table 5-1. Comparison of Modeling Approaches

EIA With Behavioral Responses

- Incorporates control costs into production function
- Includes change in quantity produced
- Includes change in market price
- Estimates impacts for
  - ✓ affected producers
  - ✓ unaffected producers
  - ✓ consumers
  - ✓ foreign trade

EIA Without Behavioral Responses

- Assumes firm absorbs all control costs
- Typically uses discounted cash flow analysis to evaluate burden of control costs
- Includes depreciation schedules and corporate tax implications
- Does *not* adjust for changes in market price
- Does *not* adjust for changes in plant production

In contrast, the behavioral approach is grounded in economic theory related to producer and consumer behavior in response to changes in market conditions. Owners of affected facilities are economic agents that can, and presumably will, make adjustments such as changing production rates or altering input mixes that will generally affect the market environment in which they operate. As producers change their behavior in response to regulation, consumers are typically faced with changes in prices that cause them to alter the quantity that they are willing to purchase. In essence, this approach models the expected reallocation of society's resources in response to a regulation. The changes in price and production from the market-level impacts are used to estimate the distribution of social costs between consumers and producers.

5.1.2 Modeling Dimension 2: Interaction Between Economic Sectors

Because of the large number of markets potentially affected by the regulation on boilers and process heaters, an issue arises concerning the level of sectoral interaction to model. In the broadest sense, all markets are directly or indirectly linked in the economy; thus, the regulation affects all commodities and markets to some extent. For example, controls on boilers and process heaters may indirectly affect almost all markets for goods and services to some extent because the cost of fuel (an input in the provision of most goods and services) is likely to increase with the regulation in effect. However, the impact of rising fuel prices will differ greatly between different markets depending on how important fuel is as an input in that market.

The appropriate level of market interactions to be included in the EIA is determined by the scope of the regulation across industries and the ability of affected firms to pass along the regulatory costs in the form of higher prices. Alternative approaches for modeling interactions between economic sectors can generally be divided into three groups:

- Partial equilibrium model: Individual markets are modeled in isolation. The only factor affecting the market is the cost of the regulation on facilities in the industry being modeled.
- General equilibrium model: All sectors of the economy are modeled together. General equilibrium models operationalize neoclassical microeconomic theory by modeling not only the direct effects of control costs, but also potential input substitution effects, changes in production levels associated with changes in market prices across all sectors, and the associated changes in welfare economywide. A disadvantage of general equilibrium modeling is that substantial time and resources are required to develop a new model or tailor an existing model for analyzing regulatory alternatives.
- Multiple-market partial equilibrium model: A subset of related markets are modeled together, with intersectoral linkages explicitly specified. To account for the relationships and links between different markets without employing a full general equilibrium model, analysts can use an integrated partial equilibrium model. The multiple-market partial equilibrium approach represents an intermediate step between a simple, single-market partial equilibrium approach and a full general equilibrium approach. This approach involves identifying and modeling the most significant subset of market interactions using an integrated partial equilibrium framework. In effect, the modeling technique is to link a series of standard partial equilibrium models by specifying the interactions between supply functions and then solving for prices and quantities across all markets simultaneously. In instances where separate markets are closely related and there are strong interconnections, there are significant advantages to estimating market adjustments in different markets simultaneously using an integrated market modeling approach.

5.2 Selected Modeling Approach for Boilers and Process Heaters Analysis

To conduct the analysis for the boilers and process heaters MACT, the Agency used a market modeling approach that incorporates behavioral responses in a multiple-market partial equilibrium model as described above. This approach allows for a more realistic assessment of the distribution of impacts across different groups than the nonbehavioral approach, which may be especially important in accurately assessing the impacts of a significant rule affecting numerous industries. Because of the size and complexity of this regulation, it is important to use a behavioral model to examine the distribution of costs across society. Because the regulations on boilers and process heaters primarily affect energy costs, an input into many production processes, complex market interactions need to be captured to provide an accurate picture of the distribution of regulatory costs. Because of the large number of affected industries under this MACT, an appropriate model should include multiple markets and the interactions between them. Multiple-market partial equilibrium analysis provides a manageable approach to incorporate interactions between energy markets and final product markets into the EIA to accurately estimate the regulation's impact.

The model used for this analysis includes energy, agriculture, manufacturing, mining, commercial, and transportation markets affected by the controls placed on boilers and process heaters.[6] The energy markets are divided into natural gas, petroleum products, coal, and electricity. The residential sector is treated as a single representative demander in the energy markets.

Figure 5-1 presents an overview of the key market linkages included in the economic impact model used for analyzing the boilers and process heaters MACT. The analysis' emphasis is on the energy supply chain and the consumption of energy by producers of goods and services. The industries most directly affected by the boilers and process heaters MACT are the electricity industry, chemical industry and pulp and paper industry. However, changes in the equilibrium prices and quantities of energy and goods and services affect all sectors of the economy. (See Figure 5-1.) This analysis explicitly models the linkages between these market segments to capture both the direct costs of compliance and the indirect costs due to changes in prices. For example, production costs will increase for chemical companies using boilers and process heaters as a result of the capital investments and monitoring costs, as well as the resulting increase in the price of electricity used as an energy input in the production process.

The economic model also captures behavioral changes of producers of goods and services that feedback into the energy markets. Changes in production levels and fuel switching in the manufacturing process affect the demand for Btus in fuel markets. The change in output is determined by the size of the cost increase per Btu (typically variable cost per output), the facility's production function (slope of supply curve), and the demand characteristics of the facility's downstream market (other market suppliers and market demanders). For example, if consumers' demand for a product is not very sensitive to price, then producers can pass the majority of the cost of the regulation through to consumers and output may not change appreciably. However, if only a small proportion of market output is produced by producers affected by the regulation, then competition will prevent the affected producers from raising their prices significantly.

One possible feedback pathway that this analysis does *not* model is technical changes in the manufacturing process. For example, if the cost of Btus increases, a facility may use measures to increase manufacturing efficiency or capture waste heat. Facilities could also possibly change the

[6]These markets are defined at the two- and three-digit NAICS code level. This allows for a fairly disaggregated examination of the regulation's impact on producers. However, if the costs of the regulation are concentrated on a particular subset of one of these markets, then treating the cost as if it fell on the entire NAICS code may still underestimate the impacts on the subset of producers affected by the regulation.

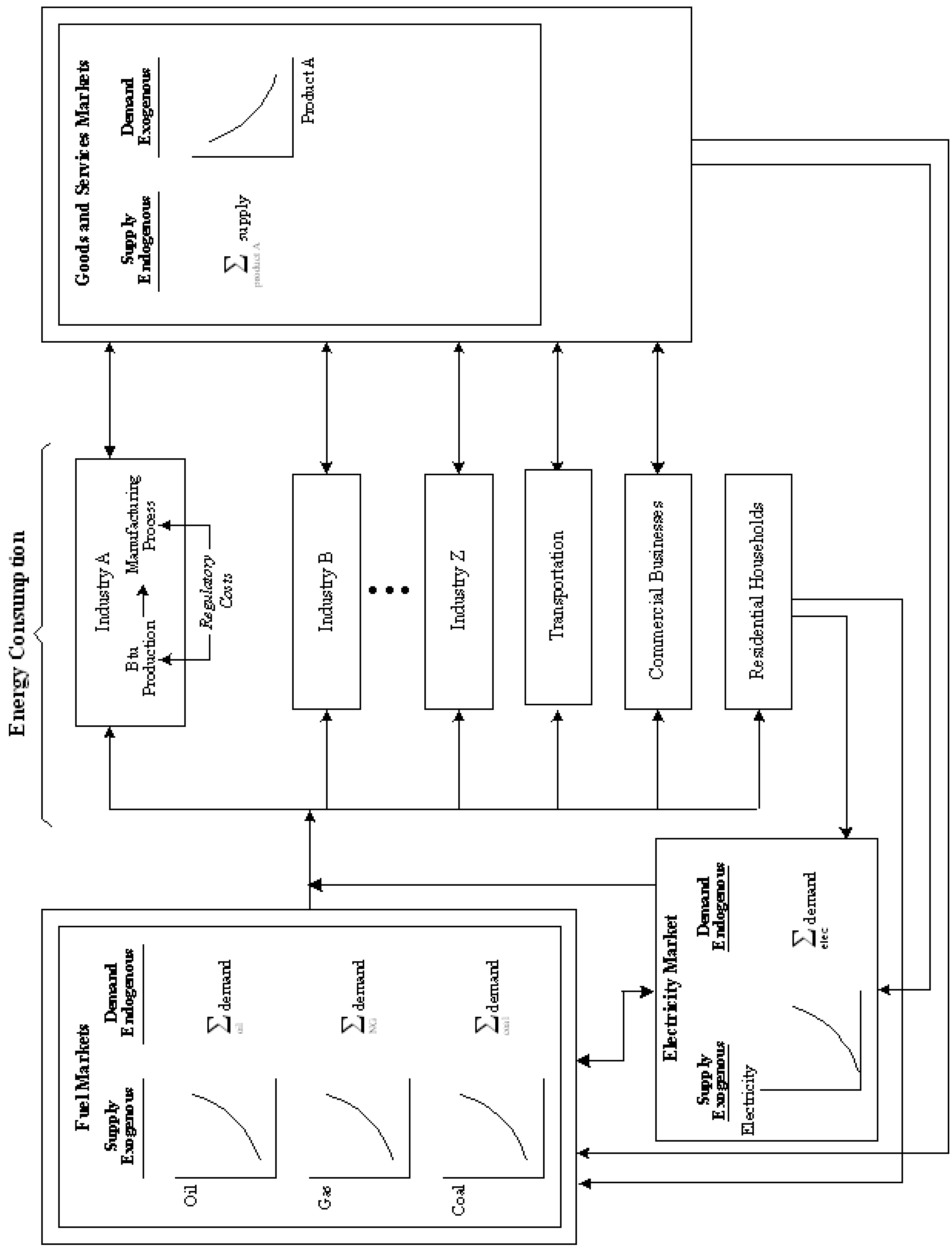


Figure 5-1. Links Between Energy and Goods and Services Markets

input mix that they use, substituting other inputs for fuel. These facility-level responses will also act to reduce pollution, but including these responses is beyond the scope of this analysis.

5.2.1 Directly Affected Markets

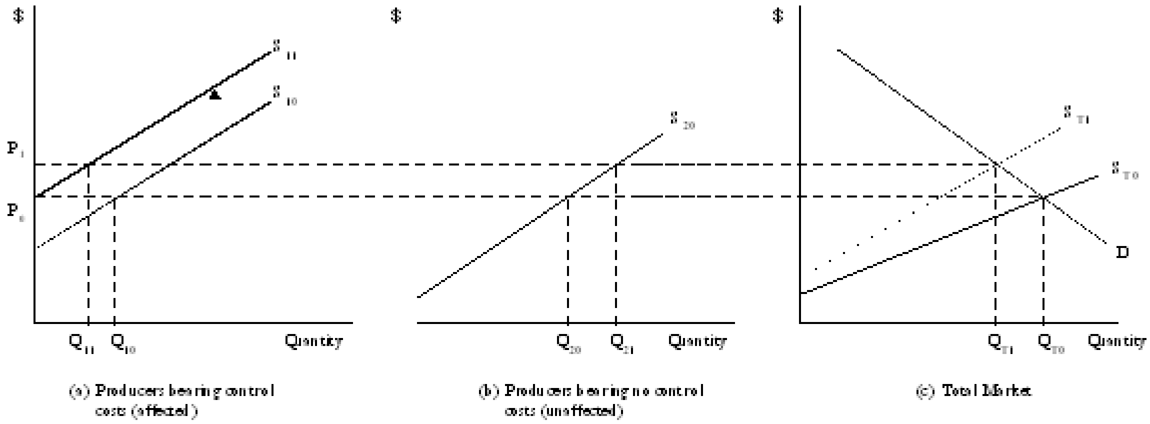
Markets where boilers and process heaters are used as an input to production are considered to be directly affected. As outlined in Chapter 3, facilities using several types of boilers or process heaters will be required to add controls. In addition, a larger population of boilers and process heaters will incur monitoring costs to comply with the regulation. Therefore, the regulation will increase their production costs and cause these directly affected firms to reduce the quantity that they are willing to supply at any given price.

5.2.1.1 Electricity Market

Boilers are used to generate power throughout the electricity industry. Even though utility boilers are not covered under this regulation, the Agency estimates over 300 industrial, commercial, and institutional boilers involved in providing electric services (SIC 4911/NAICS22111) will be affected. Most of these are owned by municipal electric service providers.

For this study, the electricity market was modeled as a nationally competitive market. The electricity market is modeled this ways primarily due to tractability concerns. Given the difficulty in ascertaining how many States would decide to deregulate their electricity markets, a competitive electricity market was the most reasonable approach for this modeling exercise. The direct costs of compliance on affected boilers lead to an upward shift in the total market supply for electricity. Figure 5-2 illustrates the shifts in the supply curve for a representative energy market. In addition to the direct costs, the market for electricity will also be indirectly affected through changes in fuel prices. Electricity generators are extremely large consumers of coal, natural gas, and petroleum products. For example, some of the impact of control costs on the petroleum industry will be on the electricity industry in the form of higher prices. Indirect costs will also lead to an upward shift in the supply curve.

The demand for electricity is derived by aggregating across the goods and services markets and the residential sector. Because of direct compliance costs on the goods and services markets, the demand curve for electricity will shift downward. Therefore, it is ambiguous whether equilibrium quantity will rise or fall. The changes in the price and quantity are determined by the relative magnitude of the shifts in the price elasticities of the supply and demand curves.



P_0 = market price without regulation

P_1 = market price with regulation

S_{10} = supply function for affected firms without regulation

S_{11} = supply function for affected firms with regulation

Q_{10} = quantity sold for affected firms without regulation

Q_{11} = quantity sold for affected firms with regulation

S_{20} = supply function for unaffected firms both with and without regulation

Q_{20} = quantity sold for unaffected firms without regulation

Q_{21} = quantity sold for unaffected firms with regulation

S_{T0} = total market supply function without regulation

S_{T1} = total market supply function with regulation

Q_{T0} = total market quantity sold without regulation

Q_{T1} = total market quantity sold with regulation

Figure 5-2. Market Effects of Regulation-Induced Costs

5.2.1.2 Petroleum Market

Control costs associated with boilers and process heaters will increase the cost of refining petroleum products. The supply curve for petroleum products will shift upward by the proportional increase in total production costs caused by the control costs on boilers and process heaters. For petroleum products, a single composite product was used to model market adjustment because boilers and process heaters are used throughout the refinement process, from distillation to reformulation. In addition, examining the full heterogeneity of petroleum products and the impacts to all specific end products would require a model of much greater complexity than this one. As a result, assigning costs to specific end products and estimating economic impacts to them, such as fuel oil #2 or reformulated gasoline, is difficult. The use of a composite product tends to understate the impacts for petroleum products where compliance costs as a percentage of production costs are greater than average and overstate impacts for products where compliance costs as a percentage of production costs are less than average.

5.2.1.3 Goods and Services Markets: Agriculture, Manufacturing, Mining, Commercial, and Transportation

Many manufacturing facilities use boilers and process heaters in their production processes to generate steam and process heat. Commercial entities use boilers for space heating and to generate supplementary electricity. In addition to the direct costs of the regulation, goods and services markets are indirectly affected through price increases in the energy markets.

Directly affected producers are segmented into sectors defined at the two- or three-digit NAICS code level. A partial equilibrium analysis was conducted for each sector to model the supply and demand. Changes in production levels and fuel switching due to the regulation's impact on the price of Btus were then linked back into the energy markets.

The impact of the regulation on producers in these sectors was modeled as an increase in the cost of Btus used in the production process. In this context, Btus refer to the generic energy requirements used to generate process heat, process steam, or shaft power. Compliance costs associated with the regulation will increase the cost of Btu production in the manufacturing sectors. The cost of Btu production for industry increases because of both direct control costs on boilers and process heaters owned by manufacturers, and increases in the price of fuels. Because Btus are an input into the production process, these price increases lead to an upward shift in the facility (and industry) supply curves as shown in Figure 5-2, leading to a change in the equilibrium market price and quantity.

The changes in equilibrium supply and demand in each market are modeled to estimate the regulation's impact on each sector. In a perfectly competitive market, the point where supply equals demand determines the market price and quantity, so market price and quantity are determined by solving the model for the price where the quantity supplied and the quantity demanded are equal. The size of the regulation-induced shifts in the supply curve is a function of the total direct control costs associated with boilers and process heaters and the indirect fuel costs (determined by the change in fuel price and intensity of use) in each goods and services market. The proportional shift in the supply curve is determined by the ratio of total control costs (both direct and indirect) to total revenue.

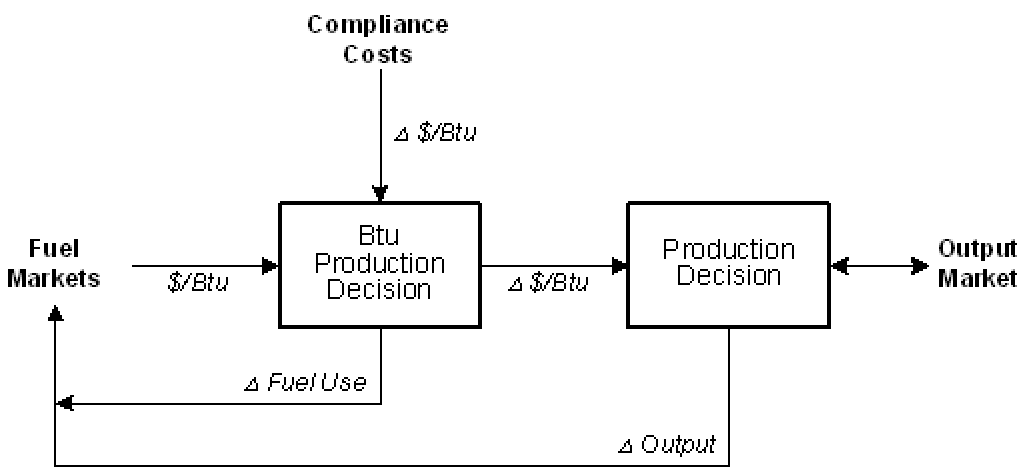


Figure 5-3. Fuel Market Interactions with Facility-Level Production Decisions

This impact on the price of Btus facing industrial users feeds back to the fuel market in two ways (see Figure 5-3). The first is through the company's input decision concerning the fuel(s) that will be used for its manufacturing process. As the cost of Btus increases, firms may switch fuels and/or change production processes to increase energy efficiency and reduce the number of Btus required per unit of output. Fuel switching impacts were modeled using cross-price elasticities of demand between energy sources. For example, a cross-price elasticity of demand between natural gas and electricity of 0.5 implies that a 1 percent increase in the price of electricity will lead to a 0.5 percent increase in the demand for natural gas. Own-price elasticities of demand are used to estimate the change in the use of fuel by demanders. For example, a demand elasticity of –0.175 for electricity implies that a 1 percent increase in the price of electricity will lead to a 0.175 percent decrease in the quantity of electricity demanded.

The second feedback pathway to the energy markets is through the facility's change in output. Because Btus are an input into the production process, energy price increases lead to an upward shift in the facility supply curves (not modeled individually). This leads to an upward shift in the industry supply curve when the shifts at the facility level are aggregated across facilities. A shift in the industry supply curve leads to a change in the equilibrium market price and quantity. In a perfectly competitive market, the point where supply equals demand determines the new market price and quantity. The Agency modeled the feedback into the energy market by assuming that the percentage change in output in the manufacturing sectors translates into a equivalent percentage change in the demand for energy (Btus). This implies that there are constant returns to scale from energy inputs in the manufacturing process over the relevant range of output and time period of analysis. This is an appropriate assumption for this analysis because the output changes in these sectors being modeled are relatively small (always less than 1 percent) and reflect short-run production decisions.[7]

The Agency assumed that the demand curves for goods and services in all sectors are unchanged by the regulation. However, because the demand function quantifies the change in quantity demanded in response to a change in price, the baseline demand conditions are important in determining the regulation's impact. The key demand parameters are the elasticities of demand with respect to changes in the price of goods and services. For these markets, a "reasonable" range of elasticity values is assigned based on estimates from similar commodities. Because price changes are anticipated to be small, the point elasticities at the original price and quantity should be applicable throughout the relevant range of prices and quantities examined in this model.

For more information on how these energy markets are modeled in this analysis, please refer to Appendix B of the RIA.

5.2.2 Indirectly Affected Markets

In addition to the many markets that are directly affected by the regulation on boilers and process heaters, some markets feel the regulation's impacts despite having no direct costs resulting from the regulation. Firms in these markets generally face changes in the price of energy that affect their production decisions.

5.2.2.1 Market for Coal

The coal market is not directly affected by the regulation, but it has the potential to be significantly affected through indirect costs. Although boilers and process heaters are not commonly used in the production or transportation of coal, the supply of coal will be affected by the price of energy used in coal production. However, the indirect impacts on coal production costs are relatively small compared to the direct impacts on the production costs in the electricity and petroleum markets; thus, the "relative" price of coal (per Btu) will decrease compared with other energy sources.

The demand for coal from the industrial sectors will be affected by differences in compliance costs by fuel type applied to boilers and process heaters in the industrial sectors. Because compliance costs are high for coal-fired units, manufacturers will switch away from coal units toward natural gas units with lower compliance costs. However, the overall impact on the demand for coal is ambiguous because the relative increase in the cost of producing Btus by burning coal will be offset by the relative decrease in the price of coal. Similarly, the demand for coal by utility generators will be affected through changes in the relative price of alternative (noncoal) energy sources and direct costs on coal boilers.

5.2.2.2 Natural Gas Market

The natural gas market is included in the economic model to complete coverage of the energy markets. EPA projects that there are no direct and minimal indirect impacts on the production costs of natural gas. However, the demand for natural gas will increase because of the relative decrease in the price of natural gas and the lower relative compliance costs for gas-fired boilers and process heaters.

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[7]Long-run production decisions of fuel switching and increased energy efficiency are captured by the cross- and own-price elasticities in the energy markets.

5.2.2.3 Goods and Services Markets

Some goods and services markets do not include any boilers or process heaters and are therefore not directly affected by the regulation. However, these markets will still be affected indirectly because of the changes in energy prices that they will face following the regulation. There will be a tendency for these users to shift away from electricity and petroleum products and towards natural gas and coal.

5.2.2.4 Impact on Residential Sector

The residential sector does not bear any direct costs associated with the regulation because this sector does not own boilers or process heaters. However, they bear indirect costs due to price increases. The residential sector is a significant consumer of electricity, natural gas, and petroleum products used for heating, cooling, and lighting, as well as many other end uses. The change in the quantity of energy demanded by these consumers in response to changes in energy prices is modeled as a single demand curve parameterized by demand elasticities for residential consumers obtained from the literature.

5.3 Operationalizing the Economic Impact Model

Figure 5-4 illustrates the linkages used to operationalize the estimation of economic impacts associated with the compliance costs. Compliance costs placed on boilers and process heaters shift the supply curve for electricity and petroleum products. Adjustments in the electricity and petroleum energy markets determine the share of the cost increases that producers (electric service providers and petroleum companies) and consumers (product manufacturers, commercial business, and residential households) bear.

The supply and demand relationships between the energy markets are fully modeled. For example, changes in electricity production feed back and affect the demand for coal, natural gas and petroleum products. Similar changes in refinery production affect the petroleum industry’s demand for electricity.

Manufacturers experience supply curve shifts due to control costs on affected boilers and process heaters they operate and changes in prices for natural gas, petroleum, electricity, and coal. The share of these costs borne by producers and consumers is determined by the new equilibrium price and quantity in the goods and services markets. Changes in manufacturers’ Btu demands due to fuel switching and changes in production levels feed back into the energy markets.

Adjustments in price and quantity in all markets occur simultaneously. A computer model was used to numerically simulate market adjustments by iterating over commodity prices until equilibrium is reached (i.e., until the quantity supplied equals the quantity demanded in all markets being modeled). Using the results provided by the model, economic impacts of the regulation (changes in consumer and producer surplus) were estimated for all sectors of the economy being modeled.

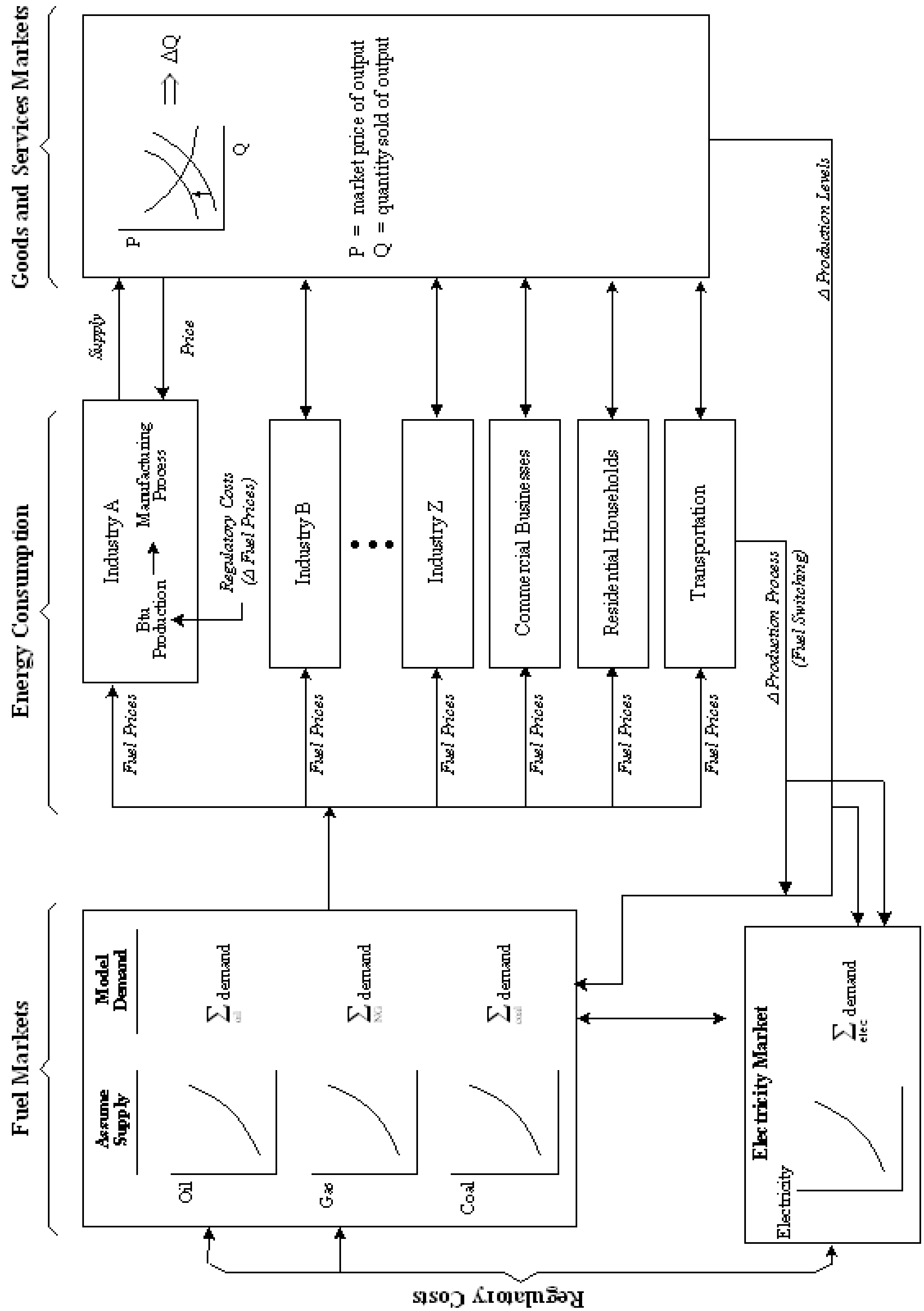


Figure 5-4. Operationalizing the Estimation of Economic Impact

5.3.1 *Computer Model*

The computer model comprises a series of computer spreadsheet modules. The modules integrate the engineering cost inputs and the market-level adjustment parameters to estimate the regulation's impact on the price and quantity in each market being analyzed. At the heart of the model is a market-clearing algorithm that compares the total quantity supplied to the total quantity demanded for each market commodity.

Current prices and production levels are used to calibrate the baseline scenario (without regulation) for the model. Then, the compliance costs associated with the regulation are introduced as a "shock" to the system, and the supply and demand for market commodities are allowed to adjust to account for the increased production costs resulting from the regulation. Using an iterative process, if the supply does not equal demand in all markets, a new set of prices is "called out" and sent back to producers and consumers to "ask" what quantities they would supply and demand based on these new prices. This technique is referred to as an auctioneer approach because new prices are continually called out until an equilibrium set of prices is determined (i.e., where supply equals demand for all markets).

Supply and demand quantities are computed at each price iteration. The market supply for each market is obtained by using a mathematical specification of the supply function, and the key parameter is the point elasticity of supply at the baseline condition. Supply elasticities are traditionally the most difficult to obtain from prior sources and analyses. As a result, EPA used an assumed value of 0.75 for 21 of the 25 manufacturing, agriculture, other mining, transportation, and commercial industries. The remaining 4 supply elasticities (for the textile mills, textile products, primary metals, and other mining industries) were obtained from a previous report conducted for EPA by E.H. Pechan and Associates, Inc (1997), and studies by Warfield, et al (2001) and the U.S. International Trade Commission (2001)[8]. EPA is currently using the last two studies to study the economic impacts of MACT standards for the Fabric Coatings, Taconite, and Steel Industries. Table 5-2 lists the supply elasticities for the markets used in the model.

The demand curves for the energy markets are the sum of demand responses across all markets. The demand for energy in the manufacturing sectors is a derived demand calculated using baseline energy usage and changes associated with fuel switching and changes in output levels. Similarly, the energy demand in residential sectors is obtained through mathematical specification of a demand function (see Appendix A).

The demand for goods and service in the two- and three-digit NAICS code manufacturing sectors is obtained by using a mathematical specification of the demand function. Demand elasticity estimates are more readily available from literature searches. The majority of demand elasticities for the manufacturing sectors were obtained from the E.H. Pechan and Associates, Inc. report (1997) prepared for the RIA of the PM NAAQS in 1997. This document reports results of a substantive literature search for elasticity estimates for use in conducting an analysis of the NAAQS. Point estimates are reported for 22 of the 25 and are derived from previous EPA analyses and selected working papers. Absent information for the remaining 3 industries (the transportation, construction, and commercial sectors), we have assumed a demand elasticity value of -1.0. Table 5-2 lists the demand elasticities for the markets used in the model.

EPA modeled fuel switching using secondary data developed by the U.S. Department of Energy for the National Energy Modeling System (NEMS). Table 5-3 contains fuel price elasticities of demand for electricity, natural gas, petroleum products, and coal. The diagonal elements in the table represent own-price elasticities. For example, the table indicates that for steam coal, a 1 percent change in the price of coal will lead to a 0.499 percent decrease in the use of coal. The off diagonal elements are cross-price elasticities and indicate fuel switching propensities. For example, for steam coal, the second column indicates that a 1 percent increase in the price of coal will lead to a 0.061 percent increase in the use of natural gas.

5.3.2 *Calculating Changes in Social Welfare*

[8]Pechan reports the results of their literature review in Appendix B. Point estimates are provided by SIC code.

The boilers and process heaters MACT will impact almost every sector of the economy, either directly through control costs or indirectly through changes in the price of energy and final products. For example, a share of control costs that originate in the energy markets is passed through the goods and services markets and borne by both the producers and consumers of their products.

Table 5-2. Supply and Demand Elasticities

		Demand Elasticities			
	Supply Elasticities	Industrial	Residential[a]	Transportation	Commercial
Petroleum	0.58[b]	Derived	–0.28	Derived	Derived
Natural Gas	0.41[b]	Derived	–0.26	Derived	Derived
Electricity	0.75[c]	Derived	–0.23	Derived	Derived
Coal	1.00[b]	Derived	–0.26	Derived	Derived
NAICS	**Description**			**Supply[d]**	**Demand[d]**
311	Food			0.75[c]	–0.30
312	Beverage and Tobacco Products			0.75[c]	–1.30
313	Textile Mills			0.37[e]	–0.85[e]
314	Textile Product Mills			0.37[e]	–0.85[e]
315	Apparel			0.75[c]	–1.80
316	Leather and Allied Products			0.75[c]	–1.20
321	Wood Products			0.75[d]	–0.20
322	Paper			1.20[c]	–1.09
323	Printing and Related Support			0.75[c]	–1.80
325	Chemicals			0.75[c]	–1.50
326	Plastics and Rubber Products			0.75[c]	–1.80
327	Nonmetallic Mineral Products			0.75[c]	–0.90
331	Primary Metals			3.50[f]	–0.80
332	Fabricated Metal Products			0.75[c]	–0.20
333	Machinery			0.75[c]	–0.50
334	Computer and Electronic Products			0.75[c]	–0.30
335	Electrical Equipment, Appliances, and Components			0.75[c]	–0.50
336	Transportation Equipment			0.75[c]	–1.00[c]
337	Furniture and Related Products			0.75[c]	–3.40
339	Miscellaneous			0.75[c]	–0.60
11	Agricultural Sector			0.75[c]	–1.80

(continued)

Table 5-2. Supply and Demand Elasticities (continued)

NAICS	Description	Supply[a]	Demand[a]
23	Construction Sector	0.75[c]	–1.00[c]
21	Other Mining Sector	0.43	–0.30
48	Transportation	0.75[c]	–0.70
Commercial	Commercial	0.75[c]	–1.00[c]

[a] U.S. Department of Energy, Energy Information Administration (EIA). "Issues in Midterm Analysis and Forecasting 1999—Table 1." <http://www.eia.doe.gov/oaif/issues/pricetbl1.html>. As obtained on May 8, 2000a.

[b] Dahl, Carol A., and Thomas E. Duggan. 1996. "U.S. Energy Product Supply Elasticities: A Survey and Application to the U.S. Oil Market." *Resource and Energy Economics*18:243-263.

[c] Assumed value.

[d] E.H. Pechan & Associates, Inc. 1997. Qualitative Market Impact Analysis for Implementation of the Selected Ozone and PM NAAQS. Appendix B. Prepared for the U.S. Environmental Protection Agency.

[e] Warfield, et al. 2001. "Multifiber Arrangement Phaseout: Implications for the U.S. Fibers/Textiles/Fabricated Products Complex." www.fibronet.com.tw/mirron/ncs/9312/mar.html> As obtained September 19, 2001.

[f] U.S. International Trade Commission (USITC). November 21, 2001. Memorandum to the Commission from Craig Thomsen, John Giamalua, John Benedetto, Joshua Levy, International Economists. Investigation No. TA-201-73: STEEL-Remedy Memorandum.

To estimate the total change in social welfare without double-counting impacts across the linked partial equilibrium markets being modeled, EPA quantified social welfare changes for the following categories:

- change in producer surplus in the energy markets;
- change in producer surplus in the goods and services markets;
- change in consumer surplus in the goods and services markets; and
- change in consumer surplus in the residential sector.

Figure 5-5 illustrates the change in producer and consumer surplus in the intermediate energy market and the goods and services markets. For example, assume a simple world with only one energy market, wholesale electricity, and one product market, pulp and paper. If the regulation increases the cost of generating wholesale electricity, then part of the cost of the regulation will be borne by the electricity producers as decreased producer surplus, and part of the costs will be passed on to the pulp and paper manufacturers. In Figure 5-5(a), the pulp and paper manufacturers are the consumers of electricity, so the change in consumer surplus is displayed. This change in consumer surplus in the energy market is captured by the product market (because the consumer is the pulp and paper industry in this case), where it is split between consumer surplus and producer surplus in those markets. Figure 5-5(b) shows the change in producer surplus in the energy market, where B represents an increase in producer surplus and C represents a decrease.

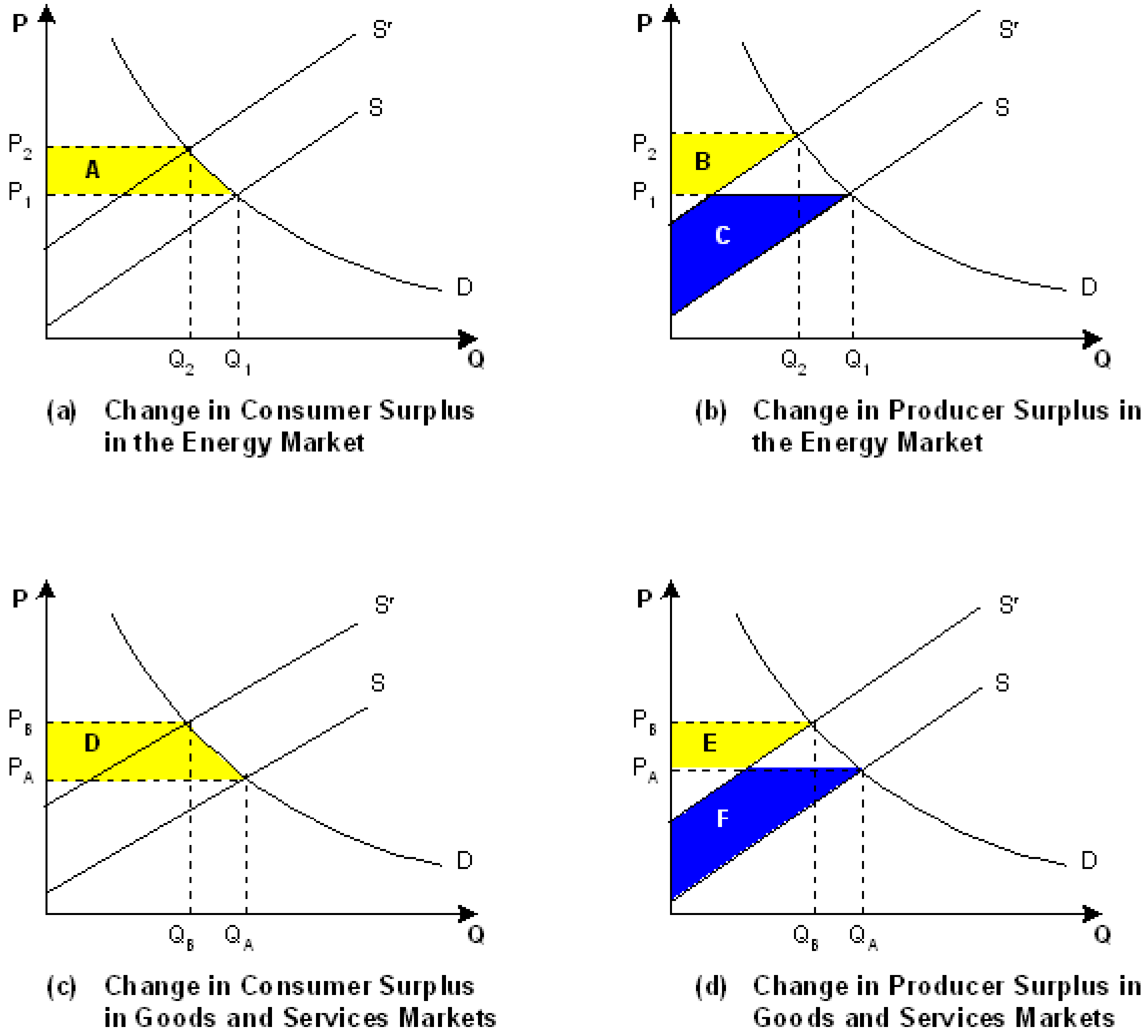
Table 5-3. Fuel Price Elasticities

	Own and Cross Elasticities				
Inputs	**Electricity**	**Natural Gas**	**Coal**	**Residual**	**Distillate**
Electricity	–0.074	0.092	0.605	0.080	0.017
Natural Gas	0.496	–0.229	1.087	0.346	0.014
Steam Coal	0.021	0.061	–0.499	0.151	0.023
Residual	0.236	0.036	0.650	–0.587	0.012
Distillate	0.247	0.002	0.578	0.044	–0.055

Source: U.S. Department of Energy, Energy Information Administration (EIA). January 2000b. *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System*. DOE/EIA-M064(2000). Washington, DC: U.S. Department of Energy.

As shown in Figures 5-5(c) and 5-5(d), the cost affects the pulp and paper industry by shifting up the supply curve in the pulp and paper market. These higher electricity prices therefore lead to costs in the pulp and paper industry that are distributed between producers and consumers of paper products in the form of lower producer surplus and lower consumer surplus. Note that the change in consumer surplus in the intermediate energy market must equal the total change in consumer and producer surplus in the product market. Thus, to avoid double-counting, the change in consumer surplus in the intermediate energy market was not quantified; instead the total change in social welfare was calculated as

$$\text{Change in Social Welfare} = \sum \Delta PSE + \sum \Delta PSF + \sum \Delta CSF + \sum \Delta CSR \quad (5.1)$$



(a) Change in Consumer Surplus in the Energy Market

(b) Change in Producer Surplus in the Energy Market

(c) Change in Consumer Surplus in Goods and Services Markets

(d) Change in Producer Surplus in Goods and Services Markets

Figure 5-5. Changes in Economic Welfare with Regulation

where

ΔPSE = change in producer surplus in the energy markets;

ΔPSF = change in producer surplus in the goods and services markets;

ΔCSF = change in consumer surplus in the goods and services markets; and

ΔCSR = change in consumer surplus in the commercial, residential, and transportation energy markets.

Appendix A contains the mathematical algorithms used to calculate the change in producer and consumer surplus in the appropriate markets. The market analysis is conducted for the year 2005 and incorporates both growth in supply and demand. The data for 2005 are based on projections of Department of Energy data and Census data, as well as projections based on the engineering data used in preparing the profile data that is an input to this analysis. Appendix A contains more information on the specific data sets and how they are used to construct a baseline data set for 2005 for use in this analysis. Both new and existing sources are evaluated using the same analysis approach.

Appendix B contains a list of key assumptions that underlie the model used to calculate economic impacts in this report, and also the results of sensitivity analyses conducted which reflect the outcomes from varying key parameters such as demand and supply elasticities.

The engineering control costs presented in Chapter 3 are inputs (regulatory "shocks") in the market model approach. The magnitude and distribution of the regulatory costs' impact on the economy depend on the relative size of the impact on individual markets (relative shift of the market supply curves) and the behavioral responses of producers and consumers in each market (measured by the price elasticities of supply and demand).

CHAPTER 6

ECONOMIC IMPACT ANALYSIS RESULTS

The underlying objective of the EIA is to evaluate the effect of the regulation on the welfare of affected stakeholders and society in general. Although the engineering cost analysis presented in Chapter 3 does represent an estimate of the resources required to comply with the rule under baseline economic conditions, the analysis does not account for the fact that the regulations may cause the economic conditions to change. For instance, producers may reduce production in the face of higher production costs, thereby reducing market supply. Moreover, the control costs may be passed along to other parties through various economic exchanges. Therefore, EPA developed an analytical structure and economic model to measure and track these effects (described in detail in Chapter 5 and the economic impact analysis). In this section, we report quantitative estimates of these welfare impacts and their distribution across stakeholders. This includes the impact on energy markets as well.

6.1 Results in Brief

The economic impacts associated with the rule are relatively low. Price increases of less than 0.02 percent are expected to occur across the many products, both energy and manufacturing, that will be affected by this rule. Reductions in output are expected to be about 0.02 percent, also. Manufacturing industries such as paper, wood products, and textiles are expected to be the most impacted. Energy prices and outputs will also experience small changes, with the largest change in energy price being a 0.05 percent increase in electricity rates. While the price and output changes associated with Option 1A are also low, the social costs increase by over $1 billion.

6.2 Social Cost Estimates

Table 6-1 summarizes the economic impact estimates for existing and new source units. Under the MACT floor alternative, EPA estimates the total change in social welfare is estimated to be $862.9 million. Under the Option 1A, welfare impacts are over twice as high as the MACT floor alternative with social welfare changes estimated to equal $1,995.5 million. Both of these estimates are slightly smaller (less than $0.3 million) than the estimated baseline engineering costs as a result of behavior changes by producers and consumers that reflect lower cost alternatives. Possible behavior responses include changes in consumption and production patterns and fuel switching.

EPA also estimated the distribution of social costs between producers and consumers and report the distribution of impacts across sectors/markets in Tables 6-2 and 6-3. Values in the text are impacts from the floor alternative; those in parentheses are impacts from the Option 1A alternative. The market analysis estimates that consumers will bear $414.3 million ($955.3 million), or 48 (48) percent of the total social cost, because of the increased prices and lower consumption levels in these markets. Producer surplus is projected to decrease by $448.7 million ($1,040.2 million), or 52 (52) percent of the total social cost as result of direct control costs, higher energy costs, and reductions in output.

Table 6-1. Social Cost Estimates ($1998 10^6)

	Change in Social Welfare, MACT Floor	Change in Social Welfare, Option 1A
Baseline engineering costs	$863.0	$1,995.8
Social costs with market adjustments	$862.9	$1,995.5
Difference between engineering and social costs	$0.1	$0.3

With exception of the natural gas market, energy producers are expected to experience producer surplus losses. Under the MACT floor, electricity, petroleum, and coal producer surplus is projected to decline by approximately $35 million. This value increases to $113 million under Option 1A. In contrast, natural gas producer surplus is projected to increase by $2 to $4 million as they benefit from increased demand from industries switching from petroleum and electricity.

The majority welfare impacts fall on the agriculture, manufacturing, and mining industries. EPA estimates total welfare losses of $609.8 million ($1,444.3 million) for these sectors. Manufacturing industries with large number of boilers and process heaters and industries that consume electricity experience the majority these losses (e.g., chemicals and allied products, paper, textile mill products, and food). Consumers in these industries experience losses of $295.2 million ($709.9 million) and producers bear $314.6 million ($734.4 million). The cost of this rule to producers as a percentage of baseline 2005 shipments is 0.011 (0.026) percent.

EPA also examined the impact on the commercial, transportation and residential sectors. The total welfare loss for the commercial sector is estimated to be $167.1 million ($301.8 million). Therefore, the regulatory burden associated with the MACT is estimated as 0.001 (0.002) total 2005 commercial sector revenues. Consumers in this sector bear approximately $71.6 million ($129.3 million) and producers bear $95.5 million ($172.5 million) of these impacts. In contrast, the total welfare loss for the transportation sector is estimated to be $9.0 million ($46.5 million). The regulatory burden associated with the rule is estimated as 0.003 (0.015) percent of total 2005

Table 6-2. Distribution of Social Costs by Sector/Market: Floor Alternative ($1998 10^6)

Sectors/Markets			Change in: Producer Surplus	Change in: Consumer Surplus	Change in: Social Welfare
Energy Markets					
Petroleum			–$1.9		
Natural gas			$4.1		
Electricity			–$33.7		
Coal			–$2.7		
Subtotal			–$34.2		
NAICS Code	**SIC Code**	**Description**			
311	20 (pt)	Food	–$28.2	–$11.3	–$39.4
312	20 (pt); 21	Beverage and Tobacco Products	–$2.4	–$4.1	–$6.5
313	22 (pt)	Textile Mills	–$22.7	–$52.0	–$74.7
314	22 (pt)	Textile Product Mills	–$0.1	–$0.1	–$0.2
315	23	Apparel	–$0.4	–$1.1	–$1.5
316	31	Leather and Allied Products	–$0.3	–$0.4	–$0.7
321	24	Wood Products	–$39.1	–$10.4	–$49.5
322	26	Paper	–$66.1	–$60.0	–$126.1
323	27	Printing and Related Support	–$0.2	–$0.4	–$0.6
325	28	Chemicals	–$40.9	–$81.8	–$122.8
326	30	Plastics and Rubber Products	–$2.2	–$5.4	–$7.6
327	32	Nonmetallic Mineral Products	–$3.4	–$4.0	–$7.4
331	33	Primary Metals	–$25.2	–$5.7	–$30.9
332	34	Fabricated Metal Products	–$8.5	–$2.3	–$10.8
333	35	Machinery	–$7.3	–$4.9	–$12.2
334	36 (pt)	Computer and Electronic Products	–$3.6	–$1.4	–$5.0
335	36 (pt)	Electrical Equipment, Appliances, and Components	–$2.5	–$1.6	–$4.1
336	37	Transportation Equipment	–$24.6	–$32.8	–$57.3
337	25	Furniture and Related Products	–$5.4	–$24.6	–$30.1
339	39	Miscellaneous	–$0.8	–$0.7	–$1.5
11	01-08	Agricultural Sector	–$0.6	–$1.3	–$1.9
23	15-17	Construction Sector	–$0.8	–$1.1	–$1.9
21	10; 14	Other Mining Sector	–$10.1	–$7.0	–$17.2
48	40-47 (pt)	Transportation	–$4.7	–$4.3	–$9.0
42; 44-45; 49; 51-56; 61-62; 71-72; 81	40-48 (pt); 50-99	Commercial	–$71.6	–$95.5	–$167.1
		Residential	NA	–$42.7	–$42.7
Grand Total			–$414.3	–$448.7	–$862.9

Table 6-3. Distribution of Social Costs by Sector/Market: Option 1A Alternative ($1998 10^6)

Sectors/Markets			Change in: Producer Surplus	Change in: Consumer Surplus	Change in: Social Welfare
Energy Markets					
Petroleum			–$27.3		
Natural gas			$2.4		
Electricity			–$79.5		
Coal			–$6.4		
Subtotal			–$110.8		
NAICS Code	**SIC Code**	**Description**			
311	20 (pt)	Food	–$90.0	–$36.0	–$126.0
312	20 (pt); 21	Beverage and Tobacco Products	–$5.4	–$9.3	–$14.7
313	22 (pt)	Textile Mills	–$45.0	–$103.2	–$148.2
314	22 (pt)	Textile Product Mills	–$0.1	–$0.3	–$0.4
315	23	Apparell	–$0.9	–$2.1	–$3.0
316	31	Leather and Allied Products	–$2.7	–$4.3	–$7.1
321	24	Wood Products	–$72.0	–$19.2	–$91.2
322	26	Paper	–$173.1	–$157.2	–$330.3
323	27	Printing and Related Support	–$0.4	–$1.0	–$1.4
325	28	Chemicals	–$102.4	–$204.7	–$307.1
326	30	Plastics and Rubber Products	–$6.1	–$14.6	–$20.7
327	32	Nonmetallic Mineral Products	–$9.1	–$10.9	–$20.0
331	33	Primary Metals	–$59.5	–$13.6	–$73.1
332	34	Fabricated Metal Products	–$18.6	–$5.0	–$23.6
333	35	Machinery	–$17.1	–$11.4	–$28.5
334	36 (pt)	Computer and Electronic Products	–$12.0	–$4.8	–$16.8
335	36 (pt)	Electrical Equipment, Appliances, and Components	–$11.7	–$7.8	–$19.6
336	37	Transportation Equipment	–$47.8	–$63.7	–$111.4
337	25	Furniture and Related Products	–$9.2	–$41.8	–$51.0
339	39	Miscellaneous	–$3.2	–$2.5	–$5.7
11	01-08	Agricultural Sector	–$1.5	–$3.6	–$5.1
23	15-17	Construction Sector	–$3.2	–$4.3	–$7.5
21	10; 14	Other Mining Sector	–$18.9	–$13.1	–$32.0
48	40-47 (pt)	Transportation	–$24.1	–$22.5	–$46.5
42; 44-45; 49; 51-56; 61-62; 71-72; 81	40-48 (pt); 50-99	Commercial	–$129.3	–$172.5	–$301.8
		Residential	NA	–$92.0	–$92.0

transportation sector revenues. Transportation consumers bear approximately $4.7 million ($24.1 million) and producers bear $4.3 million ($22.5 million) of these impacts. Finally, the social cost burden to residential consumers of energy, $42.7 million ($92.0 million), is 0.037 (0.078) percent of annual residential energy expenditures in 2005.

Sensitivity analyses of how social costs behave with changes in the demand and supply elasticities are available in Appendix B.

6.3 National Market-Level Impacts

Increases in the costs of production in the energy and final product markets due to the regulation are expected to result in changes in prices, production, and consumption from baseline levels. As shown in Table 6-4, the electricity market price increases by 0.050 (0.108) percent, while production/consumption decreases by 0.011 (0.026) percent as a result of additional control costs. A significant share of electricity is produced in the United States using coal as a primary input. Therefore, projected reductions in electricity production also lead to a decrease in demand for coal. As a result, the price and quantities of coal are projected to fall by 0.007 (0.020) percent and 0.010 (0.024) percent, respectively. In the petroleum market, the model projects small price and quantity effects (i.e., less than 0.01 percent). In the natural gas market, the model projects the market price will rise in response to increased demand (0.005 percent under both alternatives). The price increase is the result of additional control costs and increased demand. Production and consumption quantities also increase in this market (0.002 percent under the floor alternative and 0.001 percent under Option 1A) as a result of increased demand.

Additional control costs and higher energy costs associated with the regulation lead to higher goods and services prices in all markets and a decline in output. However, the changes are generally very small. Under the MACT Floor, three markets have price increases greater than or equal to 0.02 percent—Wood Product(NAICS 321), Paper (NAICS 322), and Textile Mills (NAICS 313). Under Option 1A, these three markets have price increases greater than or equal to 0.05 percent. The producers in these sectors are expected to face higher per-unit control costs relative to other industries. In addition, these industries are also electricity-intensive; therefore, costs of production also increase as a result of higher electricity prices.

Although the impacts on price and quantity in the goods and services markets are estimated to be small, one possible effect of modeling market impacts at the two and three digit NAICS code level is that fuel-intensive industries within the larger NAICS code definition may be affected more significantly than the average industry for that NAICS code. Thus, the changes in price and

Table 6-4. Market-Level Impacts

Sectors/Markets			MACT Floor Percent Change Price	MACT Floor Percent Change Quantity	Option 1A Percent Change Price	Option 1A Percent Change Quantity
Energy Markets						
Petroleum			0.002%	0.000%	0.019%	–0.005%
Natural gas			0.005%	0.002%	0.005%	0.001%
Electricity			0.050%	–0.011%	0.108%	–0.026%
Coal			–0.007%	–0.010%	–0.020%	–0.024%
NAICS Code	**SIC Code**	**Description**				
311	20 (pt)	Food	0.006%	–0.002%	0.019%	–0.006%
312	20 (pt); 21	Beverage and Tobacco Products	0.003%	–0.004%	0.007%	–0.009%
313	22 (pt)	Textile Mills	0.025%	–0.021%	0.050%	–0.043%
314	22 (pt)	Textile Product Mills	0.000%	0.000%	0.000%	0.000%
315	23	Apparel	0.000%	–0.001%	0.001%	–0.001%
316	31	Leather and Allied Products	0.002%	–0.003%	0.025%	–0.030%
321	24	Wood Products	0.041%	–0.008%	0.075%	–0.015%
322	26	Paper	0.026%	–0.028%	0.068%	–0.074%
323	27	Printing and Related Support	0.000%	0.000%	0.000%	–0.001%
325	28	Chemicals	0.009%	–0.013%	0.021%	–0.032%
326	30	Plastics and Rubber Products	0.001%	–0.002%	0.003%	–0.005%
327	32	Nonmetallic Mineral Products	0.003%	–0.003%	0.009%	–0.008%
331	33	Primary Metals	0.011%	–0.009%	0.026%	–0.021%
332	34	Fabricated Metal Products	0.003%	–0.001%	0.007%	–0.001%
333	35	Machinery	0.002%	–0.001%	0.005%	–0.002%
334	36 (pt)	Computer and Electronic Products	0.001%	0.000%	0.002%	–0.001%
335	36 (pt)	Electrical Equipment, Appliances, and Components	0.002%	–0.001%	0.009%	–0.004%
336	37	Transportation Equipment	0.004%	–0.004%	0.007%	–0.007%
337	25	Furniture and Related Products	0.008%	–0.026%	0.013%	–0.044%
339	39	Miscellaneous	0.001%	0.000%	0.003%	–0.002%
11	01-08	Agricultural Sector	0.000%	0.000%	0.001%	–0.001%
23	15-17	Construction Sector	0.000%	0.000%	0.000%	0.000%
21	10; 14	Other Mining Sector	0.012%	–0.004%	0.023%	–0.007%
48	40-47 (pt)	Transportation	0.001%	–0.001%	0.007%	–0.005%
42; 44-45; 49; 51-56; 61-62; 71-72; 81	40-48 (pt); 50-99	Commercial	0.000%	0.000%	0.001%	–0.001%

pt = Part.

quantity should be interpreted as an average for the whole NAICS code, not necessarily for each disaggregated industry within that NAICS code.

6.4 Executive Order 13211 (Energy Effects)

Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use" (66 Fed. Reg. 28355 [May 22, 2001]), requires EPA to prepare and submit a Statement of Energy Effects to the Administrator of the Office of Information and Regulatory Affairs, Office of Management and Budget, for certain actions identified as "significant energy actions." Section 4(b) of Executive Order 13211 defines "significant energy actions" as "any action by an agency (normally published in the *Federal Register*) that promulgates or is expected to lead to the promulgation of a final rule or regulation, including notices of inquiry, advance notices of proposed rulemaking, and notices of proposed rulemaking:

- that is a significant regulatory action under Executive Order 12866 or any successor order, and is likely to have a significant adverse effect on the supply, distribution, or use of energy; or

- that is designated by the Administrator of the Office of Information and Regulatory Affairs as a significant energy action."

EPA has provided additional information on the impacts of the rule on affected energy markets below.[9]

Energy Price Effects. As described in the market-level results section, electricity prices are projected to increase by less than 1 percent. Petroleum and natural gas prices are all projected to increase by less than 0.1 percent. The price of coal is projected to decrease slightly.

Impacts on Electricity Supply, Distribution, and Use. We project the increased compliance costs for the electricity market will result in an annual production decline of approximately 415 million kWh under the MACT floor and 980 million kWh under Option 1A.

Impacts on Petroleum, Natural Gas, and Coal Supply, Distribution, and Use. The model projects decreases in petroleum production/consumption of approximately 68 barrels per day under the MACT floor and 975 barrels per day under Option 1A. In contrast, natural gas production/consumption is projected to increase by 1.1 million cubic feet per day under the MACT floor and 600,000 cubic feet per day under Option 1A This is the result of fuel switching in response to relative price changes. Finally, the model also projects less than a 1,000 tons per day decrease in coal production/consumption under both scenarios in response to reduced output from the electricity sector (a significant consumer of coal). Based on these results, the Agency concludes that the industrial boiler and process heater NESHAP will not have a significant adverse effect on the supply, distribution, or use of energy.

6.5 Conclusions

The decrease in social surplus estimated using the market analysis is $862.9 million ($1,955.5 million). This estimate is slightly smaller than the estimated baseline engineering costs because the market model accounts for behavioral changes of producers and consumers. Although the rule affects boilers and process heaters used in energy industries, energy producers only incur less than 6 percent of the total social cost of the regulation. This burden is spread across numerous markets because the price of energy increases slightly as a result of the regulation, which increases the cost of production for all markets that use energy as part of their production process.

The remaining share of the social cost is mostly borne by the manufacturing sectors which operate the majority of the boilers and process heaters affected by the regulation. Manufacturing industries bearing the largest social costs include percent—Wood Products (NAICS 321), Paper (NAICS 322), and Textile Mills (NAICS 313). However, the market model predicts that changes in these industries' price and quantity do not exceed 0.02 percent under the floor alternative and 0.05 percent under Option 1A..

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[9]Conversion factors for heat rates were obtained from AEO 2002, Appendix H. These factors vary by year to year; 2010 values are reported in this Appendix.

Because of the minimal changes in price and quantity estimated for most of the affected markets, EPA expects that there would be no discernable impact on international trade. Although an increase in the price of U.S. products relative to those of foreign producers is expected to decrease exports and increase imports, the changes in price due to the industrial boilers and process heaters MACT are generally too small to significantly influence trade patterns. There may also be a small decrease in employment, but because the impact of the regulation is spread across so many industries and the decreases in market quantities are so small, it is unlikely that any particular industry will face a significant decrease in employment.

CHAPTER 7

SMALL BUSINESS IMPACTS

This chapter investigates the potential impact the regulation will have on small entities. The Agency has identified 185 small entities that will be affected by the MACT floor alternative for the industrial boilers and process heaters NESHAP. For these entities, the average cost-to-sales ratio (CSR) is 0.78 percent and the average annual control cost (in 1999 dollars) is $198,675.

7.1 Results in Brief

As listed in Table 7-1, 34 of the 185 affected entities will incur annual compliance costs that are greater than or equal to 1 percent of their annual sales or revenues, and 10 of these 34 are expected to incur annual compliance costs of 3 percent or greater of annual sales or revenues. As explained later in this chapter, the Agency has certified that this rule will not impose a significant impact on a substantial number of small entities. This certification is based on the results shown for the MACT floor alternative and on the results of the economic impact analysis shown in Chapter 6. For Option 1A, as listed in Table 7-1, there are almost twice as many small entities affected (369), and 148 (or 40 percent) of these incur annual compliance costs of greater than or equal to 1 percent of their annual sales or revenues, and 45 (or 12 percent) of the total incur annual compliance costs of 3 percent or greater of annual sales or revenues.

Table 7-1. Summary of Small Entity Impacts

	MACT Floor Alternative	Option 1A Alternative
Number of small entities	185	369
Total number of entities	576	970
Average annual control cost per small entity	$198,675	$269,842
Average control cost/sales ratio	0.78%	1.65%
Number of small entities with cost-to-sales ratios ≥1 percent	34	148
Number of small entities with cost-to-sales ratios ≥3 percent	10	45

7.2 Background on Small Business Screenings

The regulatory costs imposed on domestic producers and government entities to reduce air emissions from boilers and process heaters will have a direct impact on owners of the affected facilities. Firms or individuals that own the facilities with boilers and process heaters are typically business entities that have the capacity to conduct business transactions and make business decisions that affect the facility. The legal and financial responsibility for compliance with a regulatory action ultimately rests with these owners, who must bear the financial consequences of their decisions. Environmental regulations potentially affect all sizes of businesses, but small businesses may have special problems relative to large businesses in complying with such regulations.

The Regulatory Flexibility Act (RFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

For purposes of assessing the impacts of today’s rule on small entities, small entity is defined as: (1) a small business according to Small Business Administration (SBA) size standards by the North American Industry Classification System (NAICS) category of the owning entity. The range of small business size standards for the 40 affected industries ranges from 500 to 1,000 employees, except for petroleum refining and electric utilities. In these latter two industries, the size standard is 1,500 employees and a mass throughput of 75,000 barrels/day or less, and 4 million kilowatt-hours of production or less, respectively. (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

This section investigates characteristics of businesses and government entities that own existing boilers and process heaters affected by this rule and provides a preliminary screening-level analysis to assist in determining whether this rule is likely to impose a significant impact on a substantial number of the small businesses within this industry. The screening-level analysis employed here is a "sales test," which computes the annualized compliance costs as a share of sales/revenue for existing companies/government entities.

7.3 Identifying Small Businesses

To support the economic impact analysis of the regulation, EPA identified 2,186 (3,580) boilers and process heaters located at commercial, industrial, and government facilities that would be affected by the regulation. The population of boilers and process heaters was developed from the EPA ICCR Inventory Database version 4.1.[10] The list of boilers and process heaters contained in these databases was developed from information in the AIRS and OTAG databases, state and local permit records, and the combustion source ICR conducted by the Agency. Industry and environmental stakeholders reviewed the units contained in these databases as part of the ICCR FACA process. In addition, stakeholders contributed to the databases by identifying and including omitted units. Information was extracted from the ICCR databases to support the ICI boilers and process heaters NESHAP. This modified database containing information on only boilers and process heaters is referred to as the Inventory Database.

The small entities screening analysis for the regulation is based on the evaluation of existing owners of boilers and process heaters for which information was available. It is assumed that the size and ownership distribution of units in the Inventory Database is representative of the entire estimated population of existing boilers and process heaters. In addition, it is assumed that new sources included in the 2005 population will also be representative of the Inventory Database. However, because our analysis is based on a subset of the total population of boilers and process heaters, the number of entities identified as highly affected in this analysis may not be identical to the actual impact of the regulation on small entities.

The remainder of this section presents cost and sales information on small companies and government organizations that own existing boilers and process heaters. Also, in this section, as in previous sections, the values from the Inventory Database in the text are for the floor alternative. Following in parentheses are those for the Option 1A alternative.

7.4 Analysis of Facility-Level and Parent-Level Data

The 2,186 (3,580) units in the Inventory Database with full information were linked to 1,214 (1,881) existing facilities. As shown in Table 7-2, these 1,186 (1,521) facilities are owned by 576 (970) parent companies. The average number of facilities per company is approximately 2.0 (2.2); however, as is also illustrated in Table 7-2, several large entities in the health services industry and government sectors own many facilities with boilers and process heaters.

[10]The ICCR Inventory Database contains data for boilers, process heaters, incinerators, landfill gas flares, turbines, and internal combustion engines.

Table 7-2. Facility-Level and Parent-Level Data by Industry

SIC Code	NAICS	Description	Number of Units	Number of Facilities	Number of Parent Companies	Avg. Number of Facilities Per Parent Entity	Option 1A Alternative Number of Units	Number of Facilities	Number of Parent Companies	Avg. Number of Facilities Per Parent Entity
										1.0
										—
										—
										2.5
										—
		Mining/Quarrying—Nonmetallic Minerals								4.0
										1.3
										1.0
										1.9
		Apparel & Other Products from Fabrics								1.8
										1.8
										1.3
										1.9
		Printing, Publishing, and Related Industries								2.1
										2.7
										2.0
		Petroleum Refining and Related Industries								1.8
		Rubber and Misc. Plastics Products								1.6
										1.5

Table 7-2. Facility-Level and Parent-Level Data by Industry (continued)

SIC Code	NAICS	Description	Number of Units	Number of Facilities	Number of Parent Companies	Avg. Number of Facilities Per Parent Entity	Option 1A Alternative Number of Units	Number of Facilities	Number of Parent Companies	Avg. Number of Facilities Per Parent Entity
		Stone, Clay, Glass, and Concrete Products								1.5
		Description								1.7
		Industrial Machinery and Computer Equip.								1.5
										1.6
		Electronic and Electrical Equipment								1.3
										1.5
		Scientific, Optical, and Photographic Equipment								2.3
										1.8
										1.1
										1.0
		Electric, Gas, and Sanitary Services								1.0
										5.0
										1.9
		Wholesale Trade—Nondurable Goods								2.0
		Automotive Dealers and Gasoline Service Stations								1.0
										1.0
										—
										1.0
										—

Table 7-2. Facility-Level and Parent-Level Data by Industry (continued)

SIC Code	NAICS	Description	Number of Units	Number of Facilities	Number of Parent Companies	Avg. Number of Facilities Per Parent Entity	Number of Option 1A Units	Number of Alternative Facilities	Number of Parent Companies	Avg. Number of Facilities Per Parent Entity
										1.0
										—
										9.5
										1.4
		Engineering, Accounting, Research, Management and Related Services								1.0
										2.5
		Executive, Legislative, and General Administration								—
										2.0
		Administration of Human Resources								—
		Administration of Economic Programs								—
		National Security and International Affairs								3.0
										6.5
										9.0
										2.2

Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

Employment and sales are typically used as measures of business size. Employment, sales, population, and tax revenue data (when applicable) were collected for the 576 (970) parent companies and government entities.[11] Figure 7-1 shows the distribution of employees by parent company for the floor alternative. Employment for parent companies ranges from 5 to 608,000 employees. One hundred seventy-eight or more of the firms have fewer than 500 employees, and 55 companies have more than 25,000 employees. The distribution of parents by employment range for the above-the-floor alternative is similar to the floor alternative.

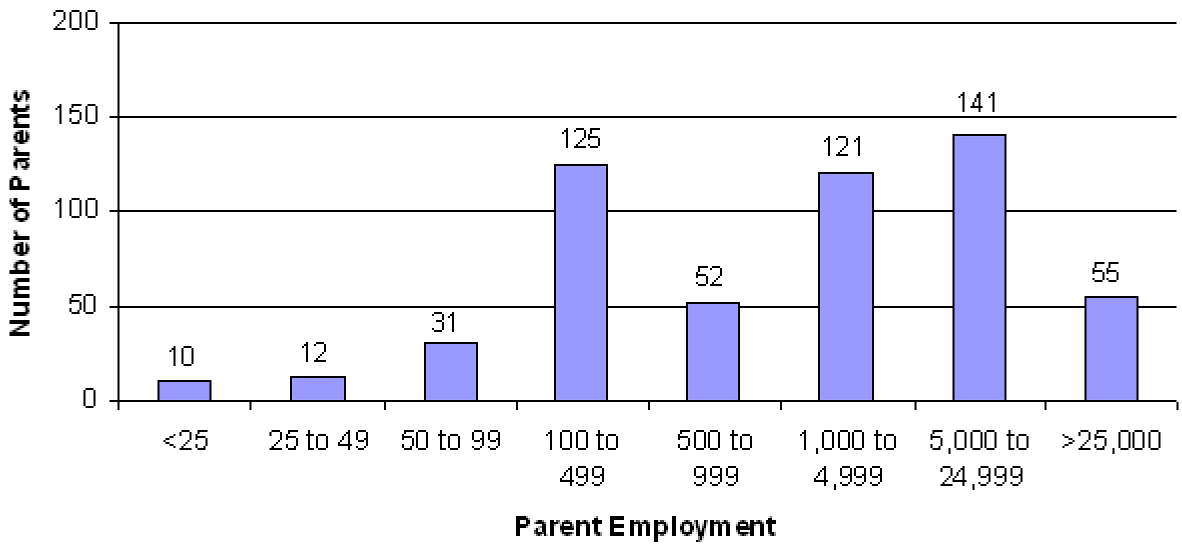

Figure 7-1. Parent Size by Employment Range, Floor Alternative

*Excludes 29 parent entities for which employment information was unavailable.

Sales provide another measure of business size. Figure 7-2 presents the sales distribution for affected parent companies for the floor alternative. The median sales figure for affected companies is $300 million ($200 million), and the average sales figure is $4.1 billion ($3.5 billion) (excluding the federal government). As shown in Figure 7-2, revenue and sales figures vary greatly across the population: 209 firms and governments affected by the floor alternative have annual revenues less than $100 million per year. These figures include all sales associated with the parent company, not just facilities affected by the

[11]Total annualized cost is compared to tax revenue to assess the relative impact on local governments.

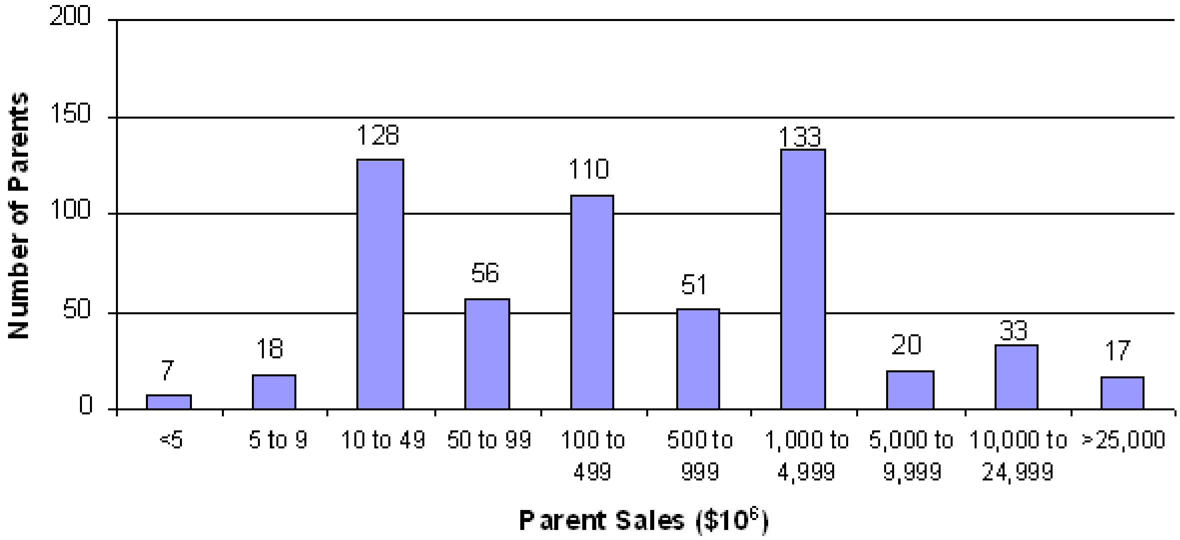

Figure 7-2. Number of Parents by Sales Range, Floor Alternative

*Excludes 3 parent entities for which sales or revenue information was unavailable.

regulation (i.e., facilities with boilers or process heaters). The distribution for the Option 1A above-the-floor alternative is similar to that for the floor alternative.

Based on SBA guidelines, 185 (369) of the companies were identified as small businesses.[12] Small businesses by business type are presented in Table 7-3. The lumber and wood products industry contains the largest number of the small businesses with 84 (134), followed by furniture and fixtures with 28 (55), electric services with 26 (30), and paper and allied products with 13 (30). The remaining small businesses are distributed across 40 different two-digit SIC code groupings.

[12]Small business guidelines typically define small businesses based on employment, and the threshold varies from industry to industry. For example, in the paints and allied products industry, a business with fewer than 500 employees is considered a small business; whereas in the industrial gases industry, a business with fewer than 1,000 employees is considered small. However, for a few industries, usually services, sales are used as the criterion. For example, in the veterinary hospital industry, companies with less than $5 million in annual sales are defined as small businesses.

Table 7-3. Small Parent Companies by Industry

SIC Code	NAICS Code	Description	Floor Alternative: Number of Parent Companies	Floor Alternative: Number of Small Parent Companies	Option 1A Alternative: Number of Parent Companies	Option 1A Alternative: Number of Small Parent Companies
01	111	Agriculture—Crops	3	—	6	1
02	112	Agriculture—Livestock	—	—	—	—
07	115	Agricultural Services	—	—	—	—
10	212	Metal Mining	2	2	2	2
12	212	Coal Mining	—	—	—	—
13	211	Oil and Gas Extraction	—	—	1	1
14	212	Mining/Quarrying—Nonmetallic Minerals	3	—	4	—
17	235	Construction—Special Trade Contractors	—	—	1	1
20	311	Food and Kindred Products	32	12	38	15
21	312	Tobacco Products	4	—	6	—
22	313	Textile Mill Products	33	5	73	27
23	315	Apparel and Other Products from Fabrics	1	—	3	2
24	321	Lumber and Wood Products	122	84	175	134
25	337	Furniture and Fixtures	67	28	100	55
26	322	Paper and Allied Products	68	13	100	30
27	511	Printing, Publishing, and Related Industries	—	—	3	2
28	325	Chemicals and Allied Products	41	4	91	19
29	324	Petroleum Refining and Related Industries	9	2	31	9
30	326	Rubber and Misc. Plastics Products	9	1	24	4
31	316	Leather and Leather Products	1	1	8	4
32	327	Stone, Clay, Glass, and Concrete Products	4	—	15	3
33	331	Primary Metal Industries	10	1	22	3
34	332	Fabricated Metal Products	7	3	18	5

(continued)

Table 7-3. Small Parent Companies by Industry (continued)

SIC Code	NAICS Code	Description	Floor Alternative: Number of Parent Companies	Floor Alternative: Number of Small Parent Companies	Option 1A Alternative: Number of Parent Companies	Option 1A Alternative: Number of Small Parent Companies
35	333	Industrial Machinery and Computer Equip.	9	1	20	5
36	335	Electronic and Electrical Equipment	3	—	19	—
37	336	Transportation Equipment	12	1	26	5
38	334	Scientific, Optical, and Photographic Equip.	3	—	9	1
39	339	Miscellaneous Manufacturing Industries	2	—	9	1
40	482	Railroad Transportation	1	—	1	—
42	484	Motor Freight and Warehousing	1	—	3	1
46	486	Pipelines, Except Natural Gas	—	—	1	—
49	221	Electric, Gas, and Sanitary Services	80	26	98	30
50	421	Wholesale Trade—Durable Goods	1	—	1	—
51	422	Wholesale Trade—Nondurable Goods	1	—	1	—
55	441	Automotive Dealers and Gasoline Service Stations	—	—	1	1
58	722	Eating and Drinking Places	—	—	—	—
59	445–454	Miscellaneous Retail	—	—	1	1
60	522	Depository Institutions	—	—	—	—
70	721	Hotels and Other Lodging Places	1	—	1	—
72	812	Personal Services	—	—	—	—
76	811	Misc. Repair Services	—	—	—	—
80	621	Health Services	2	1	2	1
81	541	Legal Services	—	—	—	—
82	611	Educational Services	30	—	35	3
83	624	Social Services	—	—	2	1

(continued)

Table 7-3. Small Parent Companies by Industry (continued)

SIC Code	NAICS Code	Description	Floor Alternative: Number of Parent Companies	Floor Alternative: Number of Small Parent Companies	Option 1A Alternative: Number of Parent Companies	Option 1A Alternative: Number of Small Parent Companies
86	813	Membership Organizations	—	—	—	—
87	541	Engineering, Accounting, Research, Management and Related Services	1	—	2	—
89	711/514	Services, N.E.C.	—	—	—	—
91	921	Executive, Legislative, and General Administration	—	—	1	—
92	922	Justice, Public Order, and Safety	—	—	—	—
94	923	Administration of Human Resources	—	—	—	—
96	926	Administration of Economic Programs	1	—	1	—
97	928	National Security and International Affairs	2	—	2	—
NA		SIC Information Not Available	—	—	2	2
State		Parent is a State Government	10	—	11	—
		Total	576	185	970	369

Source: Industrial Combustion Coordinated Rulemaking (ICCR). 1998. Data/Information Submitted to the Coordinating Committee at the Final Meeting of the Industrial Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

Fifty-nine governmental jurisdictions are affected by the final rule. The entities operate 290 units located at 121 facilities. Thirteen of these jurisdictions are classified as small because they serve a population of 50,000 or fewer. The affected small governments operate 13 units at 13 facilities. More information on impacts to these entities can be found in Section 7.6.

7.5 Small Business Impacts

Table 7-4 presents a summary of the ratio of floor and above-the-floor control costs to sales for affected large and small entities. The average CSR is 0.14 (0.23) percent for large entities

Table 7-4. Summary Statistics for SBREFA Screening Analysis: Floor and Above-the-Floor Cost-to-Sales Ratios

	Option 1A
Entities with Sales/Revenue Data	
	369
	$269,842
Compliance Cost-to-Sales/Revenue Ratios	
	176
	148
	45
	1.65
	0.77
	38.83
	0.009

(excluding the federal government) and 0.78 (1.65) percent for small entities. Forty-four (193) small parents had floor CSRs greater than 1 percent, assuming add-on control is employed to meet the standard. For these 44 (193) parent companies, the CSRs ranged from 1.00 (1.00) percent to 7.83 (38.83) percent. Ten (45) entities out of these 44 (193) had CSRs ratios greater than 3 percent.

7.6 Affected Government Entities

The RFA as amended by SBREFA provides the following standard definition of "small governmental jurisdiction": a city, county, town, township, village, school district, or special district with a population of less than fifty thousand. Using this definition, EPA identified thirteen small governmental jurisdictions that own and operate "public power" producers with affected boilers. For this part of the small entity analysis, which focuses on affected government entities, public power producers are defined as nonprofit publicly owned electrical utilities operated by municipalities, counties, and states or other publicly owned bodies such as public utility districts. This excludes rural electric cooperatives.

As illustrated in Table 7-5, the vast majority of small municipal systems with affected boilers are located in the Midwest (11 systems or 85 percent). Four of the eleven municipal systems are located in Minnesota, with two in Indiana and two in Michigan.

Table 7-5. Regional Distribution of Municipal Systems

Regional Distribution	# of Facilities
East	
Vermont	1
Midwest	
Indiana	2
Iowa	1
Michigan	2
Minnesota	4
Ohio	1
Wisconsin	1
West	
California	1
Total	13

Historically municipal utilities were set up to provide residents of a community with reliable energy. For example, the residential sector accounts more than two thirds of total consumers in all cases (see Table 7-6). However the residential sector generally represents smallest group in terms of total energy consumption. The industrial and commercial sectors consume approximately 70 percent of total energy supplied. Power not consumed by the residential, commercial or industrial sectors is sold into wholesale energy market.

Table 7-6. Selected Municipal Utilities' Capacity, Usage and Consumer Types

			Distribution of Energy Usage by Customer Type				Distribution of Customers		
ROW ID	Capacity (MW)	Energy Usage	Residential	Commercial	Industrial	Total Consumer	Residential	Commercial	Industrial
1	50.5	**332,524,000**	27%	NA	NA	**19,313**	82%	15%	3.7%
2	115	**371,823,000**	36%	28%	16%	**15,615**	87%	11%	0.3%
3	24.3	**388,066,000**	19%	10%	70%	**9,082**	84%	14%	1.0%
4	22.2	**185,191,000**	26%	14%	58%	**6,235**	86%	13%	1.6%
5	34.5	**147,335,000**	26%	27%	44%	**5,955**	86%	14%	0.3%
6	23	**573,003,000**	8%	NA	NA	**7,207**	90%	7%	1.0%
7	35	**338,903,000**	38%	8%	51%	**13,247**	87%	11%	1.3%
8	46	**194,753,000**	22%	NA	NA	**6,890**	85%	13%	0.1%
9	103.1	**837,175,000**	NA	NA	NA	**NA**	NA	NA	NA
10	32	**218,208,000**	40%	3%	55%	**10,829**	88%	3%	8.4%
11	26	**267,201,000**	16%	NA	NA	**9,471**	75%	24%	0.3%
12	34	**95,642,000**	33%	67%	NA	**5,747**	83%	17%	0.3%

Source: Giles, Ellen F. 2000. platts Directory of Electric Power Producers and Distributors 109th Edition of the Electrical World Directory. New York: McGraw Hill.

Public power producers do not pay state or local taxes. However, they typically are under agreement to make annual contributions to state and local government operating funds. In addition, they are not guaranteed at rate of return (as regulated public utilities are), however, their rates are set by agreement with local councils and these rates are typically adjusted to reflect changes in operating costs.

Municipal utilities have the ability to generate capital through the issuance of tax exempt municipal bonds. These municipal bonds are exempt from federal income tax which allows the publicly owned utilities to finance capital projects at a more affordable rate. Additionally the local governments investing in municipal utilities generally issue revenue bonds rather than general obligation bonds. This ensures that the debit can be paid back through revenues from the generation of electricity and does not obligate the local government or community tax base.

As shown in Table 7-7, the average total annual compliance costs per entity are $223 thousand under the floor alternative and increase to $548 thousand for the above –the- floor alternative (Option 1A). For the floor alternative, the median cost-to-revenue ratio is 0.94 percent and ratios range from less than 0.5 percent to 8 percent. Three of the affected small governments have cost-to-revenue ratios at or above 3 percent. Similar analysis for the above the MACT floor alternative shows the median cost-to-revenue ratio is 2.2 percent and ratios range from less than 0.5 percent to 16 percent. Five of the thirteen affected small governments have cost-to-revenue ratios at or above 3 percent.

Table 7-7. Summary of Impacts to Small Government Entities

	Floor	Option 1A
Total Number of Small Entities	13	13
Average Total Annual Compliance Cost (TACC) per Small Entity ($)	$ 223	$ 548
Compliance Costs are <1% of Revenue	7	2
Compliance Costs are 1 to 3% of Revenue	3	6
Compliance Costs are >=3% of Revenue	3	5
Average Compliance Cost as a % of Revenue	1.67	4.18
Median	0.94	2.21
Maximum	7.83	16.30
Minimum	0.02	0.02

Source: American Public Power Association (APPA). 2002. *Straight Answers to False Charges about Public Power*. Washington D.C.: APPA. As obtained on November 13, 2003 at http://www.appanet.org/about/publicpower/index.cfm .

7.6 Assessment of SBREFA Screening

This analysis indicates that over two-thirds of the parent companies affected by the industrial boilers and process heaters standard are large companies.[13] The relatively small proportion of small businesses affected by the regulation at the floor level is due in part to the exclusion of ICI boilers and process heaters with less than 10 MMBtu input capacity that also use a fossil fuel liquid or gas as primary fuel. As a result, a large share of small boilers and process heaters, which are presumably owned disproportionately by smaller entities, will not incur compliance costs. The Agency estimates that approximately 57 percent of the U.S. population are less than 10 MMBtus or are emergency units and, hence, are excluded from the proposed regulation for the floor alternative. These units are included, however, in the Option 1A above-the-floor alternative, except where they consume a fossil fuel liquid or gas other than residual fuel oil.

[13]Based on SBA guidelines for determining small businesses.

Of the small businesses affected by the regulation, the majority are in the lumber and wood products, furniture and fixtures, paper and allied products, and electric, gas and sanitary services sectors. As shown in Table 7-5, the median profit margin for these four sectors is approximately 3 percent. Table 7-5 also shows the profit margins for the other industry sectors with affected small businesses. All profit margins of industry sectors with affected small businesses are above 2 percent.

After considering the economic impact of today's rule on small entities, EPA certifies that

Table 7-5. Profit Margins for Industry Sectors with Affected Small Businesses

SIC Code	NAICS Code	Description	Median Profit Margin
20	311	Food and Kindred Products	3.6%
22	313	Textile Mill Products	2.1%
24	321	Lumber and Wood Products	3.0%
25	337	Furniture and Fixtures	3.0%
26	322	Paper and Allied Products	3.3%
28	325	Chemicals and Allied Products	2.7%
49	221	Electric, Gas, and Sanitary Services	7.5%

Source: Dun & Bradstreet. 1997. *Industry Norms & Key Business Ratios*. Desktop Edition 1996-97. Murray Hill, NJ: Dun & Bradstreet, Inc.

this action will not have a significant impact on a substantial number of small entities. In accordance with the RFA, as amended by the SBREFA, 5 U.S.C. 601, et. seq., EPA conducted an assessment of the standard on small businesses within the industries affected by the rule. Based on SBA size definitions for the affected industries and reported sales and employment data, the Agency identified 185 of the 576 companies, or 32 percent, owning affected facilities as small businesses. Although small businesses represent 32 percent of the companies within the SBREFA screening population, they are expected to incur only 8 percent of the total compliance costs of $445.6 million (1998$) for the evaluated 576 firms. Only ten small firms have compliance costs equal to or greater than 3 percent of their sales. In addition, only 24 small firms have CSRs between 1 and 3 percent.

An EIA was performed to estimate the changes in product price and production quantities for this rule. As mentioned in the summary of economic impacts earlier in this report, the estimated changes in prices and output for affected firms are no more than 0.04 percent.

This analysis indicates that the rule should not generate a significant impact on a substantial number of small entities for following reasons. First, only 31 small firms (or 17 percent of all affected small firms) have compliance costs equal to or greater than 1 percent of their sales. Of these, only ten small firms (or 5 percent of all affected small firms) have compliance costs equal to or greater than 3 percent of their sales. Second, the EIA results show minimal impacts on prices and output from affected firms, including small entities, due to implementing this rule. This analysis therefore allows us to certify that there will not be a significant impact on a substantial number of small entities from the implementing this rule.

This rule will not have a significant economic impact on a substantial number of small entities as a result of several decisions EPA made regarding the development of this rulemaking which resulted in limiting the impact of this rule on small entities. First, as mentioned earlier, EPA identified small units (heat input of 10 MMBtu/hr or less) and limited-use boilers (operate less than 10 percent of the time) as separate subcategories from large units. Many small and limited-use units are located at small entities. As also discussed earlier, the result of the MACT floor analysis for these subcategories of existing sources was that no MACT floor could be identified except for the limited-use solid fuel subcategory, which is less stringent than the MACT floor for large units. Furthermore, the results of the above-the-floor analysis for these subcategories indicated that the costs would be too high to be considered feasible. Consequently, this rule contains no emission limitations for any of the existing small and limited-use subcategories except the existing limited-use solid fuel subcategory. In addition, the alternative metals emission limit resulted in minimizing the impacts on small entities because some of the potential entities burning a fuel containing very little metals are small entities. Finally, the risk-based alternative compliance options for HCl and manganese sources may also serve to mitigate impacts to small entities.

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CHAPTER 8

EMISSIONS INVENTORIES AND AIR QUALITY CHANGES

8.1 Results in Brief

An analysis of changes in air quality associated with implementation of the industrial boilers and process heaters MACT rule shows that the majority of the U.S. population in 2005 will live in areas with predicted improvement in annual average visibility of between 0.4 to 0.6 deciviews resulting from the rule. Almost 4 percent of the projected 2005 U.S. population are predicted to experience improved annual average visibility of greater than 0.25 deciviews. Furthermore, roughly 10 percent of the projected 2005 U.S. population will benefit from reductions in annual average visibility of greater than 0.1 deciviews. The mean improvement across all U.S. counties is 0.05 deciviews, or almost 2 percent from baseline visibility levels. In urban areas (i.e., areas with a population of 250,000 or more), the mean improvement in annual visibility was 0.06 deciviews. In rural areas (i.e. all non-urban areas), the mean improvement in visibility was 0.04 deciviews in 2005.

On average, the Eastern U.S. experienced slightly larger absolute but smaller relative improvements in visibility than the Western U.S. from the emission reductions associated with this rule.

8.2 Introduction

Executive Order 12866 as amended by E.O. 13258 contains as one its requirements the assessment of benefits for any major rule, where a major rule is one that meets one or more of the 4 criteria listed in Chapter 1 of this RIA. Since this regulation is a major rule according to the Executive Order, we have undertaken to estimate the benefits associated with implementation of this regulation. Assessing the benefits requires knowledge of the emission reductions resulting from application of this rule, the change in air quality due to the emission reductions, and the locations where these emission reductions and air quality changes take place. This chapter of the RIA presents the baseline emissions upon which the emission reductions are calculated and the changes in air quality resulting from the emission reductions.

While this regulation is intended to reduce HAP emissions, including mercury, from industrial boilers and process heaters, it also provides reductions in non-HAP species such as particulate matter (PM) and sulfur dioxide (SO_2). Reductions in PM and SO_2 are those that are the focus of the benefits assessment, for we currently have sufficient information to monetize the benefits from reductions of these pollutants. We currently lack sufficient information to monetize the benefits from the HAP and mercury reductions from this regulation. It is quite possible that the benefits from the 58,575 tons of HAP reductions and the 1.7 tons of mercury emission reductions may be substantial.

8.3 Baseline Emissions

We measure air quality impact as a change in concentration in PM in the counties affected by the emission reductions taking place due to implementation of this regulation. In this case, changes in particulate matter less than 10 microns (PM_{10}) and changes in the particulate matter fraction of less than 2.5 microns ($PM_{2.5}$) are calculated in this analysis. Calculations of changes in both PM fractions are necessary in order to provide a more complete assessment of benefits. In addition, changes in visibility are also estimated in order to calculate the benefits associated with this category of effects. In order to determine the air quality impact of the emission reductions, we first calculated a baseline, then took the PM and SO_2 emission reductions prepared in the engineering analysis, estimated the $PM_{2.5}$ reductions from the PM_{10} reductions, and then entered the emission reductions into an air quality model. This section describes how the baseline inventories were determined.

8.3.1 EPA's Baseline Inventory

Initially, our plan was to utilize the same baseline and control scenarios being analyzed to estimate the control costs. The baseline inventory for the control costs is the Industrial Combustion Coordinated Rulemaking (ICCR) inventory database, which was developed to support the rulemakings for the Combustion Turbines and Reciprocating Internal Combustion Engine MACTs as well as this MACT. However, we were unable to use this baseline inventory because it did not contain a number of data fields necessary for air quality modeling and possessed incomplete data at the unit level necessary for such modeling. Instead, we included 1996 National Emission Trends (NET) inventory data for these sources to augment the ICCR data in order to prepare an inventory with sufficient data for the air quality modeling. The NET inventory provides baseline emissions data of criteria pollutants from point, area, and mobile sources. Version 3.12 of the NET is being used to prepare the baseline inventory for this air quality analysis. The ICCR inventory provides the PM and SO_2 emissions. All other pollutant emissions used to establish the baseline inventory are taken from the NET. Readers desiring more information about the inventory methodologies or results should consult those documents for details.

The baseline reflects air quality and emissions present in 1996, therefore, it reflects controls from various air pollution programs that are implemented by 1996. To the extent that additional controls are implemented before 2005, the year of analysis in this report, the air quality results would differ but the extent of the difference cannot be determined. To our knowledge, only phase II of the the Acid Rain Program which was implemented at utility sources nationwide in 2000 could influence baseline emission inventories. For more details see Pechan, 2001.

The analysis uses a baseline inventory with a base year of 1996 to estimate the benefits of the regulation in 2005. We determined that minimal changes in unit population and baseline emissions would occur between the current time and 2005, so that the use of this inventory without imposition of growth factors was deemed adequate.

8.3.2 The MACT floor and Other Emissions Reduction Scenarios

Table 8-1 summarizes the baseline PM_{10}, $PM_{2.5}$, and SO_2 emissions and emission reductions nationwide for the MACT floor option. Baseline emission and emission reductions nationwide for Option 1A, an above-the-MACT floor option, are presented in Appendix C of the RIA. These regulatory options are described in Chapter 1 of the RIA. The air quality analysis presumes no change in volatile organic compound (VOC), nitrogen oxides (NOx), carbon monoxide (CO), and ammonia (NH_3) emissions. Hence, the baseline emissions for these pollutants are not shown in this table. For these baseline emissions, refer to Pechan, 2001.

The split of emission reductions shown in the latter two columns results from the assignment of specific control devices to only a portion of the affected units. The emissions reductions associated with this portion, which is slightly more than half of the known affected units, can be included in the benefits model (described in Chapter 10 of the RIA) for calculation of the benefits from these reductions. This is true since these emission reductions can be linked to decreased exposures to affected populations. For the emission reductions from the other affected others, we employ a benefits transfer method that takes the benefits values estimated for the units with assigned control devices and transfers them to these remaining emission reductions to estimate the resulting monetized benefits. For more information on the benefits transfer method, refer to Chapter 10.

As mentioned earlier in this chapter, we conducted no air quality modeling for the HAP or the mercury emission reductions that occur from implementation of this regulation. These emission reductions are listed in Table 8-2. For a description of how HAP emissions and emission factors are estimated for this rule, refer to the emission factors/emissions estimates memo in the public docket (ERG, 2002).

Table 8-1. Summary of Nationwide Baseline Emissions and Emission Reductions[a] for the MACT floor, Existing Units Only[b,c] in 2005

Pollutant	Source Type	1996 Baseline Emissions (tons/year)	MACT Floor Option Emission		Total Emission Reductions for MACT floor option	Option 1A Emission Reductions		
			Known Affected Units	Unknown Affected Units		Known Affected Units	Unknown Affected Units	Total
SO_2								
	Point	3,745,790	82,542	30,394	112,936	95,361	41,372	136,733
	Area	1,397,425	-					
	Motor Vehicle	302,938	-					
	Nonroad	840,167	-					
PM_{10}								
	Point	1,167,995	266,491	298,109	564,600	313,947	255,282	569,229
	Area	30,771,607	-					
	Motor Vehicle	294,764	-					
	Nonroad	463,579	-					

$PM_{2.5}$						
	Point	576,022	75,095	84,125	159,220	94,565 76,894 171,459
	Area	6,675,777	-			
	Motor Vehicle	230,684	-			
	Nonroad	410,334	-			

[a] Reductions are Baseline Emissions - Control Scenario Emissions. All emissions estimates are in tons.

[b] The totals reflect emissions for the 48 contiguous States, excluding Alaska and Hawaii.

[c]The totals do not reflect new source emissions and emission reductions. These emission reductions were not considered in the air quality modeling since they were far smaller that those for existing units (484 tons for PM_{10} from new units, versus 564,600 tons from existing units). The differences between such emission reductions for $PM_{2.5}$ are identical, since $PM_{2.5}$ emissions are derived from PM_{10} emissions. Also, the differences between SO_2 emission reductions for existing and new units are just as great.

Table 8-2. HAP Emission Reductions for the MACT floor option, 2005

Existing Sources Only

Pollutant	**Emission Reductions (tons/year)** **MACT floor**
HCl	42,100
Pb	105
Hg	1.7
Non-mercury metals[a]	1,080
Selected inorganics[b]	18,000
Total HAP reductions	58,350

[a]Non-mercury metals include: arsenic, beryllium, cadmium, chromium, manganese, and nickel.

[b]Selected inorganics include: chlorine, hydrofluoric acid, and phosphorus.

8.4 Air Quality Impacts

This section summarizes the methods for and results of estimating air quality for the baseline and control scenarios. Based on the emissions inventories described above, ambient particulate matter (PM_{10} and $PM_{2.5}$) concentrations are projected from the S-R Matrix developed from the Climatological Regional Dispersion Model (CRDM). In Section 8.3.1, we provide brief background on the S-R Matrix model. In Section 8.3.2, we estimate PM air quality, and in Section 8.3.3, we estimate visibility degradation. Visibility degradation (i.e., regional haze), is developed using empirical estimates of light extinction coefficients and efficiencies in combination with modeled reductions in pollutant concentrations.

8.4.1. PM Air Quality Modeling

EPA used the emissions inputs described above with a national-scale source-receptor (S-R) Matrix to evaluate the effects of the milestone reductions on ambient concentrations of both PM_{10} and $PM_{2.5}$. Ambient concentrations of PM are composed of directly emitted particles and of secondary aerosols of sulfate, nitrate, ammonium, and organics.

The S-R Matrix was developed from multiple simulations of the CRDM using meteorological data for 1990 coupled with emissions data from version 2.0 of the 1990 National Particulate Inventory (NPI). Relative to more sophisticated and resource-intensive three-dimensional modeling approaches, the CRDM and its associated S-R Matrix do not fully account for all the complex chemical interactions that take place in the atmosphere in the secondary formation of PM. Instead it relies on more simplistic species dispersion–transport mechanisms supplemented with chemical conversion at the receptor location.

The S-R Matrix consists of fixed-coefficients that reflect the relationship between annual average PM concentration values at a single receptor in each county (i.e., a hypothetical monitor sited at the county population centroid) and the contribution by PM species to this concentration from each emission source (E.H. Pechan, 1996). The modeled receptors include all U.S. county centroids as well as receptors in 10 Canadian provinces and 29 Mexican cities/states. The methodology used here for estimating PM air quality concentrations is detailed in Pechan-Avanti (2000) and is similar to the method used in the July 1997 PM and Ozone NAAQS RIA (U.S. EPA, 1997e) and the RIA for the final Regional Haze Rule (U.S. EPA, 1999a), and the Tier 2/Gasoline Sulfur Rule (US EPA, 1999c).

8.4.2 PM Air Quality Results

This section presents the projected reductions in particulate matter concentrations resulting from reductions in SO_2 and PM_{10}, with $PM_{2.5}$ emissions being derived from the PM_{10} emissions using the PM Calculator tool[14] for the final rule (MACT floor). The results for the above-the-floor option, Option 1A, are presented in Appendix C of the RIA.

8.4.2.1 MACT Floor Option

Table 8-3 provides a summary of the predicted ambient PM_{10} and $PM_{2.5}$ concentrations from the S-R matrix for the 2005 baseline and changes associated with the rule. The results indicate that the predicted change in PM concentrations is composed almost entirely of reductions in fine particulates ($PM_{2.5}$) with little or no reduction in coarse particles (PM_{10} less $PM_{2.5}$). Therefore, the observed changes in PM_{10} are composed primarily of changes in $PM_{2.5}$. In addition to the standard frequency statistics (e.g., minimum, maximum, average, median), Table 8-3 provides the population-weighted average which better reflects the baseline levels and predicted changes for more populated areas of the nation. This measure, therefore, will better reflect the potential benefits of these predicted changes through exposure changes to these populations. As shown, the average annual mean concentrations of $PM_{2.5}$ across all U.S. grid-cells declines by roughly 0.8 percent, or 0.09 $\mu g/m^3$. The population-weighted average annual mean $PM_{2.5}$ concentration declined by 0.7 percent, or 0.10

[14] The PM Calculator Tool can be found on the Internet at www.epa.gov/chief/software/pmcalc/index.html.

μg/m^3, which is roughly similar in absolute terms to the spatial average. This indicates the rule generates roughly equivalent absolute air quality improvements in less populated, rural areas as in more populated, urban areas.

Table 8-3.

Summary of 2005 Base Case PM Air Quality and Changes Due to MACT Floor Option: Industrial Boiler/Process Heater Source Categories

Statistic	*2005 Baseline*	*Change*[a]	*Percent Change*
PM_{10}			
Minimum Annual Mean (μg/m^3) [b]	6.09	-0.07	-1.2%
Maximum Annual Mean (μg/m^3) [b]	69.30	-0.03	-0.1%
Average Annual Mean (μg/m^3)	22.68	-0.32	-1.4%
Median Annual Mean (μg/m^3)	21.84	-0.36	-1.6%
Population-Weighted Average Annual Mean (μg/m^3) [c]	28.79	-0.33	-1.1%
$PM_{2.5}$			
Minimum Annual Mean (μg/m^3) [b]	0.74	-0.01	0.0%
Maximum Annual Mean (μg/m^3) [b]	30.35	-0.71	-2.3%
Average Annual Mean (μg/m^3)	11.15	-0.09	-0.8%
Median Annual Mean (μg/m^3)	11.11	-0.11	-1.1%
Population-Weighted Average Annual Mean (μg/m^3) [c]	13.50	-0.10	-0.7%

[a] The change is defined as the control case value minus the baseline value.

[b] The baseline minimum (maximum) is the value for the populated county with the lowest (highest) annual average. The change relative to the baseline is the observed change for the populated county with the lowest (highest) annual average in the baseline.

[c] Calculated by summing the product of the projected 2005 county population and the estimated 2005 PM concentration for that county, and then dividing by the total population in the 48 contiguous States.

Table 8-4 provides information on the 2005 populations that will experience improved PM air quality. There are significant populations that live in areas with meaningful reductions in annual mean $PM_{2.5}$ concentrations resulting from the rule. As shown, just over 2 percent of the 2005 U.S. population are predicted to experience reductions of greater than 0.5 μg/m^3. Furthermore, almost 8 percent of the 2005 U.S. population will benefit from reductions in annual mean $PM_{2.5}$ concentrations of greater than 0.2 μg/m^3 and slightly over 28 percent will live in areas with reductions of greater than 0.1 μg/m^3. This information indicates how widespread the improvements in PM air quality are expected to be and the large populations that will benefit from these improvements.

Table 8-4.

Distribution of PM2.5 Air Quality Improvements Over 2005 Population Due to MACT Floor Option: Industrial Boiler/Process Heater Source Categories

Change in Annual Mean $PM_{2.5}$ Concentrations ($\mu g/m^3$)	*2005 Population*	
	Number (millions)	*Percent (%)*
$0 > \Delta\ PM_{2.5}\ Conc \leq 0.05$	105.0	37.1%
$0.05 > \Delta\ PM_{2.5}\ Conc \leq 0.1$	56.3	19.9%
$0.1 > \Delta\ PM_{2.5}\ Conc \leq 0.25$	57.2	20.2%
$0.25 > \Delta\ PM_{2.5}\ Conc \leq 0.5$	17.1	6.1%
$0.5 > \Delta\ PM_{2.5}\ Conc \leq 1.0$	4.5	1.6%
$1.0 > \Delta\ PM_{2.5}\ Conc \leq 2.0$	1.3	0.5%
$\Delta\ PM_{2.5}\ Conc > 2.0$	0.2	0.1%

[a] The change is defined as the control case value minus the baseline value.

Table 8-5 provides additional insights on the changes in PM air quality resulting from the final rule. The information presented previously in Table 8-3 illustrated the absolute and relative changes for different points along the distribution of baseline 2005 PM concentration levels, e.g., the change reflects the lowering of the minimum predicted baseline concentration rather than the minimum predicted change for 2005. The latter is the focus of Table 8-5 as it presents the distribution of predicted changes in both absolute terms (i.e., $\mu g/m^3$) and relative terms (i.e., percent) across individual grid-cells. Therefore, it provides more information on the range of predicted changes that as shown, the absolute reduction in annual mean PM_{10} concentration ranged from a low of 0.00 $\mu g/m^3$ to a high of 16.89 $\mu g/m^3$, while the relative (or percent) reduction ranged from a low of 0.0 percent to a high of 50.5 percent. Alternatively, for mean $PM_{2.5}$, the absolute reduction ranged from 0.00 to 4.65 $\mu g/m^3$, while the relative reduction ranged from 0.0 to 29.4 percent.

Table 8-5.

Summary of Absolute and Relative Changes in PM Air Quality Due to MACT Floor Option: Industrial Boiler/Process Heater Source Categories

Statistic	*PM_{10} Annual Mean*	*$PM_{2.5}$ Annual Mean*
Absolute Change from 2005 Baseline ($\mu g/m^3$)[a]		
Minimum	0.00	0.00
Maximum	-16.89	-4.65
Average	-0.32	-0.09
Median	-0.16	-0.05

Population-Weighted Average [c]	-0.33	-0.10
Relative Change from 2005 Baseline (%)[b]		
Minimum	0.00%	0.00%
Maximum	-50.52%	-29.37%
Average	-1.32%	-0.70%
Median	-0.78%	-0.50%
Population-Weighted Average [c]	-1.26%	-0.71%

[a] The absolute change is defined as the control case value minus the baseline value for each county.

[b] The relative change is defined as the absolute change divided by the baseline value, or the percentage change, for each county. The information reported in this section does not necessarily reflect the same county as is portrayed in the absolute change section.

[c] Calculated by summing the product of the projected 2005 county population and the estimated 2005 county PM absolute/relative measure of change, and then dividing by the total population in the 48 contiguous states.

For this standard, the MACT floor was chosen as the final alternative. For more information on the choice of this option as the alternative, please refer to Chapter 1 of this RIA and the preamble.

It should be noted that air quality modeling runs using the S-R matrix are available for cases in which only PM emission reductions occur and only SO_2 reductions occur. These runs are necessary as inputs to the benefits transfer method that estimates monetized benefits for emissions from sources that are not linked to a specific control device. Results from these pollutant-specific runs are presented in the technical support document (Pechan, 2001). The benefits transfer method is explained in Chapter 10, and results from the use of that method are also shown in that chapter.

8.4.3. Visibility Degradation Estimates

Visibility degradation is often directly proportional to decreases in light transmittal in the atmosphere. Scattering and absorption by both gases and particles decrease light transmittance. To quantify changes in visibility, our analysis computes a light-extinction coefficient, based on the work of Sisler (1996), which shows the total fraction of light that is decreased per unit distance. This coefficient accounts for the scattering and absorption of light by both particles and gases, and accounts for the higher extinction efficiency of fine particles compared to coarse particles. Fine particles with significant light-extinction efficiencies include sulfates, nitrates, organic carbon, elemental carbon (soot), and soil (Sisler, 1996).

Based upon the light-extinction coefficient, we also calculated a unitless visibility index, called a “deciview,” which is used in the valuation of visibility. The deciview metric provides a linear scale for perceived visual changes over the entire range of conditions, from clear to hazy. Under many scenic conditions, the average person can generally perceive a change of one deciview. The higher the deciview value, the worse the visibility. Thus, an improvement in visibility is a decrease in deciview value.

Table 8-6 provides the distribution of visibility improvements across the 2005 U.S. population resulting from the industrial boilers and process heaters rule. The majority of the 2005

U.S. population live in areas with predicted improvement in annual average visibility of between 0.4 to 0.6 deciviews resulting from the rule. As shown, almost 4 percent of the 2005 U.S. population are predicted to experience improved annual average visibility of greater than 0.25 deciviews. Furthermore, roughly 10 percent of the 2005 U.S. population will benefit from reductions in annual average visibility of greater than 0.1 deciviews. The information provided in Table 8-6 indicates how widespread the improvements in visibility are expected to be and the share of populations that will benefit from these improvements.

Because the visibility benefits analysis distinguishes between general regional visibility degradation and that particular to Federally-designated Class I areas (i.e., national parks, forests, recreation areas, wilderness areas, etc.), we separated estimates of visibility degradation into "residential" and "recreational" categories. The estimates of visibility degradation for the "recreational" category apply to Federally-designated Class I areas, while estimates for the "residential" category apply to non-Class I areas. Deciview estimates are estimated using outputs from the S-R matrix for the 2005 baseline and the MACT floor, which are the same scenarios for which changes in PM_{10} and $PM_{2.5}$ concentrations are estimated and shown earlier in this chapter. Deciview estimates for Option 1A are presented in Appendix C of this RIA

Table 8-6.

Distribution of Populations Experiencing Visibility Improvements in 2005 Due to MACT Floor Option: Industrial Boiler/Process Heater Source Categories

Improvements in Visibility [a] *(annual average deciviews)*	*2005 Population*	
	Number (millions)	*Percent (%)*
Δ *Deciview* = 0	46.0	16.3%
0 > Δ *Deciview* ≤ 0.05	168.5	59.5%
0.05 > Δ *Deciview* ≤ 0.1	41.1	14.5%
0.1 > Δ *Deciview* ≤ 0.15	11.5	4.1%
0.15 > Δ *Deciview* ≤ 0.25	5.9	2.1%
0.25 > Δ *Deciview* ≤ 0.5	3.7	3.1%
Δ *Deciview* > 0.5	1.1	0.4%

[a] The change is defined as the MACT Floor control case deciview level minus the baseline deciview level.

8.4.4 Residential Visibility Improvements

Air quality modeling results predict that the rule will create improvements in visibility through the country. In Table 8-7, we summarize residential visibility improvements across the Eastern and Western U.S. in 2005. The baseline annual average visibility for all U.S. counties is 21.2 deciviews. The mean improvement across all U.S. counties is 0.05 deciviews, or almost 2 percent. In urban areas (i.e., areas with a population of 250,000 or more), the mean improvement in annual visibility was 0.06 deciviews. In rural areas (i.e. all non-urban areas), the mean improvement in visibility was 0.04 deciviews in 2005.

On average, the Eastern U.S. experienced slightly larger absolute but smaller relative improvements in visibility than the Western U.S. from the industrial boilers and process heaters emission reductions. In Eastern U.S., the mean improvement was 0.05 deciviews from an average baseline of 22.00 deciviews. Western counties experienced a mean improvement of 0.01 deciviews from an average baseline of 17.82 deciviews projected in 2005. Overall, the data suggest that the rule has the potential to provide some improvements in visibility across the U.S. in 2005.

Table 8-7.

Summary of 2005 Baseline Visibility and Changes by Region for the MACT Floor Option: Residential

(Annual Average Deciviews)

Regions[a]	*2005 Baseline*	*Change*[b]	*Percent Change*
Eastern U.S.	22.00	-0.05	-0.2%
Urban	22.95	-0.06	-0.3%
Rural	21.62	-0.05	-0.2%
Western U.S.	17.82	-0.01	-0.1%
Urban	19.19	-0.01	-0.1%
Rural	17.55	-0.01	-0.1%
National, all counties	21.19	-0.05	-0.2%
Urban	22.49	-0.06	-0.3%
Rural	20.72	-0.04	-0.2%

[a] Eastern and Western regions are separated by 100 degrees West longitude. Background visibility conditions differ by region.

[b] An improvement in visibility is a decrease in deciview value. The change is defined as the MACT Floor control case deciview level minus the baseline deciview level.

8.4.5. Recreational Visibility Improvements

In Table 8-8, we summarize recreational visibility improvements by region in 2005 in Federal Class I areas. These recreational visibility regions are shown in Figure 8-1. As shown, the national improvement in visibility for these areas is 0.1 percent, or 0.02 deciviews. Predicted relative visibility improvements are the largest in the Eastern U.S. as shown for the Southeast (0.4%), and the Northeast/Midwest (2.3%). The Southwest and California regions are predicted to have the smallest relative visibility improvement at 0.0 percent, or 0.00 deciview decline from the baseline.

Table 8-8.

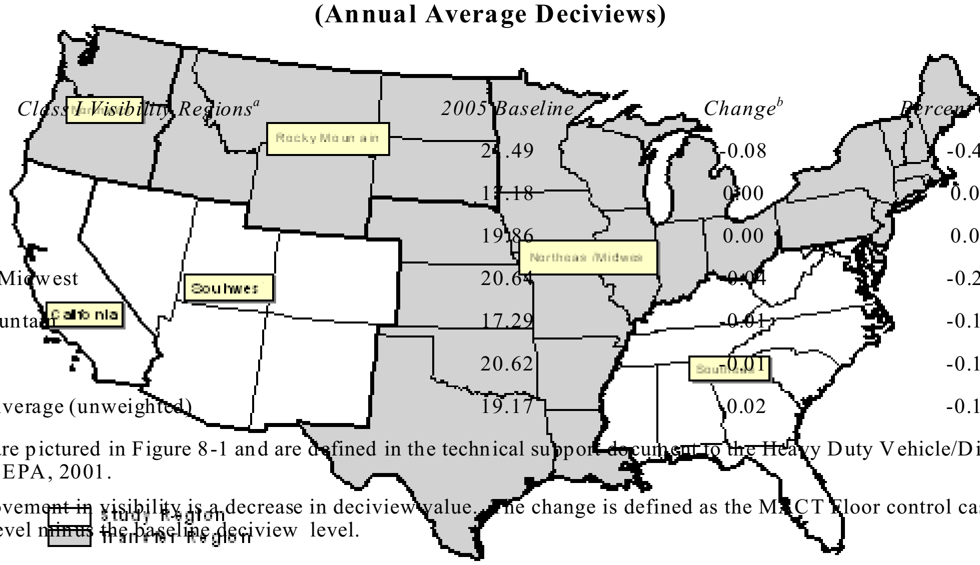
Summary of 2005 Baseline Visibility and Changes by Region for the MACT Floor Option: Recreational

(Annual Average Deciviews)

Class I Visibility Regions[a]	*2005 Baseline*	*Change*[b]	*Percent Change*
Southeast	2[illegible].49	-0.08	-0.4%
Southwest	1[illegible].18	0.00	0.0%
California	19.86	0.00	0.0%
Northeast/Midwest	20.64	-0.04	-0.2%
Rocky Mountain	17.29	-0.01	-0.1%
Northwest	20.62	-0.01	-0.1%
National Average (unweighted)	19.17	-0.02	-0.1%

[a] Regions are pictured in Figure 8-1 and are defined in the technical support document to the Heavy Duty Vehicle/Diesel Fuel TSD, U.S. EPA, 2001.

[b] An improvement in visibility is a decrease in deciview value. The change is defined as the MACT Floor control case deciview level minus the baseline deciview level.



Note: Study regions were represented in the Chestnut and Rowe (1990a, 1990b) studies used in evaluating the benefits of visibility improvements, while transfer regions used extrapolated study results. These are referred to in the Heavy Duty Vehicle/Diesel Fuel Benefits TSD (U.S. EPA, 2000).

Figure 8-1. Recreational Visibility Regions for Continental U.S.

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CHAPTER 9

QUALITATIVE ASSESSMENT OF BENEFITS OF EMISSION REDUCTIONS

The emission reductions achieved by this environmental regulation will provide benefits to society by improving environmental quality. In this chapter, and the following chapter, information is provided on the types and levels of social benefits anticipated from the Industrial and Commercial Boilers and Process Heaters NESHAP. This chapter discusses the health and welfare effects associated with the HAPs and other pollutants emitted by affected boilers and process heaters. The following chapter places a monetary value on a portion of the benefits that are described here.

In general, the reduction of HAP emissions, including mercury, resulting from the regulation will reduce human and environmental exposure to these pollutants and thus, reduce potential adverse health and welfare effects. This chapter provides a general discussion of the various components of total benefits that may be gained from a reduction in HAPs and mercury through this NESHAP. The rule will also achieve reductions of particulate matter (PM), both coarse (PM_{10}) and fine ($PM_{2.5}$) particle fractions, and sulfur dioxide (SO_2), which results in additional health and welfare benefits above those achieved by the HAP reductions. HAP benefits are presented separately from the benefits associated with other pollutant reductions.

9.1 Identification of Potential Benefit Categories

The benefit categories associated with the emission reductions predicted for this regulation can be broadly categorized as those benefits which are attributable to reduced exposure to HAPs, and those attributable to reduced exposure to other pollutants. Several of the HAPs associated with this regulation have been classified as known or probable human carcinogens. As a result, one of the benefits of the proposed regulation is a reduction in the risk of cancer. Other benefit categories include: reduced incidence of neurological effects and irritations of the lungs and skin, reduced mortality and other morbidity effects associated with PM and SO_2 (as it transforms into PM). In addition to health impacts occurring as a result of reductions in HAPs and other pollutant emissions, there are welfare impacts which can also be identified. In general, welfare impacts include effects on crops and other plant life, materials damage, soiling, visibility impairment, and acidification of water bodies. Each category is discussed separately in the following section.

9.2 Qualitative Description of Air Related Benefits

The health and welfare benefits of HAPs, including mercury, PM, and SO_2 reductions are summarized separately in the discussions below.

9.2.1 *Benefits of Reducing HAP Emissions*

According to baseline emission estimates, the source categories affected by this currently emits approximately 102,927 tons per year of HAPs at existing sources including about 11 tons of mercury and it is estimated that by the year 2005, new boilers and process heaters will emit 1,548 tons per year of HAPs and 0.4 tons of mercury. This totals 104,474 tons of HAPs and 11.4 tons of mercury annually at all boiler and process heater sources. The regulation will reduce approximately 58,575 tons of emissions of HAPs and 1.9 tons of mercury at new and existing sources by 2005. For more information on these HAP emissions and emission reductions, please refer to Chapter 8 of this RIA and the docket for this rule.

Human exposure to these HAPs may occur directly through inhalation or indirectly through ingestion of food or water contaminated by HAPs or through exposure to the skin. HAPs may also enter terrestrial and aquatic ecosystems through atmospheric deposition. HAPs can be deposited on vegetation and soil through wet or dry deposition. HAPs may also enter the aquatic environment from the atmosphere via gas exchange between surface water and the ambient air, wet or dry deposition of particulate HAPs and particles to which HAPs adsorb, and wet or dry deposition to watersheds with subsequent leaching or runoff to bodies of water (EPA,1992a). This analysis is focused only on the air quality benefits of HAP reduction.

9.2.1.1 *Health Benefits of HAP and Mercury Reductions.*

The HAP emission reductions achieved by this rule are expected to reduce exposure to ambient concentrations of arsenic, cadmium, chromium, hydrogen chloride, hydrogen flouride, lead, manganese, mercury, and nickel, which will reduce a variety of adverse health effects considering both cancer and noncancer endpoints. Information for each pollutant to be reduced by this rule is obtained from the *Integrated Risk Information System (IRIS),* an EPA system for disseminating information about the effects of several chemicals emitted to the air and /or water, and classifying these chemicals by cancer risk (IRIS, 2000). These adverse health effects include chronic health disorders (e.g., irritation of the lung, skin, and mucus membranes and effects on the blood, digestive tract, kidneys, and central nervous system), and acute health disorders (e.g., lung irritation and congestion, alimentary effects such as nausea and vomiting, and effects on the central nervous system). EPA has classified several of these HAPs as known or probable human carcinogens.

The EPA does not have the type of current detailed data on each of the facilities covered by the emissions standards for this source category, and the people living around the facilities, that would be necessary to conduct an analysis to determine the actual population exposures to the HAP emitted from these facilities and potential for resultant health effects. Therefore, the EPA does not know the extent to which the adverse health effects described above occur in the populations surrounding these facilities. However, to the extent the adverse effects do occur, the rule will reduce emissions and subsequent exposures. Health effects associated with the significant HAPs emitted from boilers and process heaters are discussed below.

Arsenic

Acute (short term) high-level inhalation exposure to arsenic dust or fumes has resulted in gastrointestinal effects (nausea, diarrhea, abdominal pain), and central and peripheral nervous system disorders. Chronic (long-term) inhalation exposure to inorganic arsenic in humans is associated with irritation of the skin and mucous membranes. Human data suggest a relationship between inhalation exposure of women working at or living near metal smelters and an increased risk of reproductive effects, such as spontaneous abortions. Inorganic arsenic exposure in humans by the inhalation route has been shown to be strongly associated with lung cancer, while ingestion of inorganic arsenic in humans has been linked to a form of skin cancer and also to bladder, liver, and lung cancer. EPA has classified inorganic arsenic as a Group A, known human carcinogen.

Cadmium

The acute (short-term) effects of cadmium inhalation in humans consist mainly of effects on the lung, such as pulmonary irritation. Chronic (long-term) inhalation or oral exposure to cadmium leads to a build-up of cadmium in the kidneys that can cause kidney disease. Cadmium has been shown to be a developmental toxicant in animals, resulting in fetal malformations and other effects, but no conclusive evidence exists in humans. An association between cadmium exposure and an increased risk of lung cancer has been reported from human studies, but these studies are inconclusive due to confounding factors. Animal studies have demonstrated an increase in lung cancer from long-term inhalation exposure to cadmium. EPA has classified cadmium as a Group B1, probable carcinogen.

Chromium

Chromium may be emitted in two forms, trivalent chromium (chromium III) or hexavalent chromium (chromium VI). The respiratory tract is the major target organ for chromium VI toxicity, for acute (short-term) and chronic (long-term) inhalation exposures. Shortness of breath, coughing, and wheezing have been reported from acute exposure to chromium VI, while perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, and other respiratory effects have been noted from chronic exposure. Limited human studies suggest that chromium VI inhalation exposure may be associated with complications during pregnancy and childbirth, while animal studies have not reported reproductive effects from inhalation exposure to chromium VI. Human and animal studies have clearly established that inhaled chromium VI is a carcinogen, resulting in an increased risk of lung cancer. EPA has classified chromium VI as a Group A, human carcinogen.

Chromium III is less toxic than chromium VI. The respiratory tract is also the major target organ for chromium III toxicity, similar to chromium VI. Chromium III is an essential element in humans, with a daily intake of 50 to 200 micrograms per day recommended for an adult. The body can detoxify some amount of chromium VI to chromium III. EPA has not classified chromium III with respect to carcinogenicity. For this rule, EPA has not determined the species of chromium emitted at industrial boilers and process heaters.

Hydrogen chloride

Hydrogen chloride, also called hydrochloric acid, is corrosive to the eyes, skin, and mucous membranes. Acute (short-term) inhalation exposure may cause eye, nose, and respiratory tract irritation and inflammation and pulmonary edema in humans. Chronic (long-term) occupational exposure to hydrochloric acid has been reported to cause gastritis, bronchitis, and dermatitis in workers. Prolonged exposure to low concentrations may also cause dental discoloration and erosion. No information is available on the reproductive or developmental effects of hydrochloric acid in humans. In rats exposed to hydrochloric acid by inhalation, altered estrus cycles have been reported in females and increased fetal mortality and decreased fetal weight have been reported in offspring. EPA has not classified hydrochloric acid for carcinogenicity.

Hydrogen fluoride

Acute (short term) inhalation exposure to gaseous hydrogen fluoride can cause severe respiratory damage in humans, including severe irritation and pulmonary edema.

Lead

Lead is a very toxic element, causing a variety of effects at low dose levels. Brain damage, kidney damage, and gastrointestinal distress may occur from acute (short-term) exposure to high levels of lead in humans. Chronic (long-term) exposure to lead in humans results in effects on the blood, central nervous system (CNS), blood pressure, and kidneys. Children are particularly sensitive to the chronic effects of lead, with slowed cognitive development, reduced growth and other effects reported. Reproductive effects, such as decreased sperm count in men and spontaneous abortions in women, have been associated with lead exposure. The developing fetus is at particular risk from maternal lead exposure, with low birth weight and slowed postnatal neurobehavioral development noted. Human studies are inconclusive regarding lead exposure and cancer, while animal studies have reported an increase in kidney cancer from lead exposure by the oral route. EPA has classified lead as a Group B2 pollutant, probable human carcinogen[15].

Manganese

Health effects in humans have been associated with both deficiencies and excess intakes of manganese. Chronic (long-term) exposure to low levels of manganese in the diet is considered to be nutritionally essential in humans, with a recommended daily allowance of 2 to 5 milligrams per day (mg/d). Chronic exposure to high levels of manganese by inhalation in humans results primarily in central nervous system (CNS) effects. Visual reaction time, hand steadiness, and eye-hand coordination were affected in chronically-exposed workers. Manganism, characterized by feelings of weakness and lethargy, tremors, a mask-like face, and psychological disturbances, may result from chronic exposure to higher levels. Impotence and loss of libido have been noted in male workers afflicted with manganism attributed to inhalation exposures. EPA has classified manganese in Group D, not classifiable as to carcinogenicity in humans.

Nickel

Nickel is an essential element in some animal species, and it has been suggested it may be essential for human nutrition. Nickel dermatitis, consisting of itching of the fingers, hand and forearms, is the most common effect in humans from chronic (long-term) skin contact with nickel. Respiratory effects have also been reported in humans from inhalation exposure to nickel. No information is available regarding the reproductive or developmental effects of nickel in humans, but animal studies have reported such effects. Human and animal studies have reported an increased risk of lung and nasal cancers from exposure to nickel refinery dusts and nickel subsulfide. Animal studies of soluble nickel compounds (i.e., nickel carbonyl) have reported lung tumors. EPA has classified nickel refinery subsulfide as Group A, human carcinogens and nickel carbonyl as a Group B2, probable human carcinogen.

Mercury

Mercury emitted from industrial boiles and other natural and man-made sources is carried by winds through the air and eventually is deposited to water and land. Recent estimates (which are highly uncertain) of annual total global mercury emissions from all sources (natural and anthropogenic) are about 5,000 to 5,500 tons per year (tpy). Of this total, about 1,000 tpy are estimated to be natural emissions and about 2,000 tpy are estimated to be contributions through the natural global cycle of re-emissions of mercury associated with past anthropogenic activity. Current anthropogenic emissions account for the remaining 2,000 tpy. Point sources such as fuel combustion; waste incineration; industrial processes; and metal ore roasting, refining, and processing are the largest point source categories on a world-wide basis. Given the global estimates noted above, U.S. anthropogenic mercury emissions are estimated to account for roughly 3 percent of the global total, and U.S. utilities are estimated to account for about 1 percent of total global emissions. Mercury exists in three forms: elemental mercury, inorganic mercury compounds (primarily mercuric chloride), and organic mercury compounds (primarily methylmercury). Mercury is usually released in an elemental form and later converted into methylmercury by bacteria. Methylmercury is more toxic to humans than other forms of mercury, in part because it is more easily absorbed in the body (EPA, 1996).

If the deposition is directly to a water body, then the processes of aqueous fate, transport, and transformation begin. If deposition is to land, then terrestrial fate and transport processes occur first and then aqueous fate and transport processes occur once the mercury has cycled into a water body. In both cases, mercury may be returned to the atmosphere through resuspension. In water, mercury is transformed to methylmercury through biological processes and for exposures affected by this rulemaking, methylmercury is considered to be the form of greatest concern. Once mercury has been

[15] In addition to the information provided in IRIS, another detailed discussion of the benefits of reducing lead emissions can be found in the Final Report to Congress on Benefits and Costs of the Clean Air Act, 1970 to 1990 (EPA 410-R-97-002).

transformed into methylmercury, it can be ingested by the lower trophic level organisms where it can bioaccumulate in fish tissue (i.e., concentrations of mercury remain in the fish's system for a long period of time and accumulates in the fish tissue as predatory fish consume other species in the food chain). Fish and wildlife at the top of the food chain can, therefore, have mercury concentrations that are higher than the lower species, and they can have concentrations of mercury that are higher than the concentration found in the water body itself. In addition, when humans consume fish contaminated with methylmercury, the ingested methymercury is almost completely absorbed into the blood and distributed to all tissues (including the brain); it also readily passes through the placenta to the fetus and fetal brain (EPA, 2001a).

Based on the findings of the National Research Council, EPA has concluded that benefits of Hg reductions would be most apparent at the human consumption stage, as consumption of fish is the major source of exposure to methylmercury. At lower levels, documented Hg exposure effects may include more subtle, yet potentially important, neurodevelopmental effects. Some subpopulations in the U.S., such as: Native Americans, Southeast Asian Americans, and lower income subsistence fishers, may rely on fish as a primary source of nutrition and/or for cultural practices. Therefore, they consume larger amounts of fish than the general population and may be at a greater risk to the adverse health effects from Hg due to increased exposure. In pregnant women, methylmercury can be passed on to the developing fetus, and at sufficient exposure may lead to a number of neurological disorders in children. Thus, children who are exposed to low concentrations of methylmercury prenatally may be at increased risk of poor performance on neurobehavioral tests, such as those measuring attention, fine motor function, language skills, visual-spatial abilities (like drawing), and verbal memory. The effects from prenatal exposure can occur even at doses that do not result in effects in the mother. Mercury may also affect young children who consume fish contaminated with Hg. Consumption by children may lead to neurological disorders and developmental problems, which may lead to later economic consequences.

In response to potential risks of mercury-contaminated fish consumption, EPA and FDA have issued fish consumption advisories which provide recommended limits on consumption of certain fish species for different populations. EPA and FDA are currently developing a joint advisory that has been released in draft form. This newest draft FDA-EPA fish advisory recommends that women and young children reduce the risks of Hg consumption in their diet by moderating their fish consumption, diversifying the types of fish they consume, and by checking any local advisories that may exist for local rivers and streams. This collaborative FDA-EPA effort will greatly assist in educating the most susceptible populations. Additionally, the reductions of Hg from this regulation may potentially lead to fewer fish consumption advisories (both from federal or state agencies), which will benefit the fishing community. Currently 44 states have issued fish consumption advisories for non-commercial fish for some or all of their waters due to contamination of mercury. The scope of FCA issued by states varies considerably, with some warnings applying to all water bodies in a state and others applying only to individual lakes and streams. Note that the absence of a state advisory does not necessarily indicate that there is no risk of exposure to unsafe levels of mercury in recreationally caught fish. Likewise, the presence of a state advisory does not indicate that there is a risk of exposure to unsafe levels of mercury in recreationally caught fish, unless people consume these fish at levels greater than those recommended by the fish advisory.

Reductions in methylmercury concentrations in fish should reduce exposure, subsequently reducing the risks of mercury-related health effects in the general population, to children, and to certain subpopulations. Fish consumption advisories (FCA) issued by the States may also help to reduce exposures to potential harmful levels of methylmercury in fish (although some studies have shown limited knowledge of and compliance with advisories by at risk populations (May and Burger, 1996; Burger, 2000)). To the extent that reductions in mercury emissions reduces the probability that a water body will have a FCA issued, there are a number of benefits that will result from fewer advisories, including increased fish consumption, increased fishing choices for recreational fishers, increased producer and consumer surplus for the commercial fish market, and increased welfare for subsistence fishing populations.

There is a great deal of variability among individuals in fish consumption rates; however, critical elements in estimating methylmercury exposure and risk from fish consumption include the species of fish consumed, the concentrations of methylmercury in the fish, the quantity of fish consumed, and how frequently the fish is consumed. The typical U.S. consumer eating a wide variety of fish from restaurants and grocery stores is not in danger of consuming harmful levels of methylmercury from fish and is not advised to limit fish consumption. Those who regularly and frequently consume large amounts of fish, either marine or freshwater, are more exposed. Because the developing fetus may be the most sensitive to the effects from methylmercury, women of child-bearing age are regarded as the population of greatest interest. The EPA, Food and Drug Administration, and many States have issued fish consumption advisories to inform this population of protective consumption levels.

The EPA's 1997 Mercury Study RTC supports a plausible link between anthropogenic releases of Hg from industrial and combustion sources in the U.S. and methylmercury in fish. However, these fish methylmercury concentrations also result from existing background concentrations of Hg (which may consist of Hg from natural sources, as well as Hg which has been re-emitted from the oceans or soils) and deposition from the global reservoir (which includes Hg emitted by other countries). Given the current scientific understanding of the environmental fate and transport of this element, it is not possible to quantify how much of the methylmercury in locally-caught fish consumed by the U.S. population is contributed by U.S. emissions relative to other sources of Hg (such as natural sources and re-emissions from the global pool). As a result, the relationship between Hg emission reductions from Utility Units and methylmercury concentrations in fish cannot be calculated in a quantitative manner with confidence. In addition, there is uncertainty regarding over what time period these changes would occur. This is an area of ongoing study.

Given the present understanding of the Hg cycle, the flux of Hg from the atmosphere to land or water at one location is comprised of contributions from: the natural global cycle; the cycle perturbed by human activities; regional sources; and local sources. Recent advances allow for a general understanding of the global Hg cycle and the impact of the anthropogenic sources. It is more difficult to make accurate generalizations of the fluxes on a regional or local scale due to the site-specific nature of emission and deposition processes. Similarly, it is difficult to quantify how the water deposition of Hg leads to an increase in fish tissue levels. This will vary based on the specific characteristics of the individual lake, stream, or ocean.

9.2.1.2 *Welfare Benefits of HAP Reductions.*

The welfare effects of exposure to HAPs have received less attention from analysts than the health effects. However, this situation is changing, especially with respect to the effects of toxic substances on ecosystems. Over the past ten years, ecotoxicologists have started to build models of ecological systems which focus on interrelationships in function, the dynamics of stress, and the adaptive potential for recovery. Chronic sub-lethal exposures may affect the normal functioning of individual species in ways that make it less than competitive and therefore more susceptible to a variety of factors including disease, insect attack, and decreases in habitat quality (EPA, 1991). All of these factors may contribute to an overall change in the structure (i.e., composition) and function of the ecosystem.

The adverse, non-human biological effects of HAP emissions include ecosystem and recreational and commercial fishery impacts. Atmospheric deposition of HAPs directly to land may affect terrestrial ecosystems. Atmospheric deposition of HAPs also contributes to adverse aquatic ecosystem effects. This not only has adverse implications for individual wildlife species and ecosystems as a whole, but also the humans who may ingest contaminated fish and waterfowl.

A number of wildlife species are a risk from consuming mercury-contaminated fish (Duvall and Baron, 2000). Mercury can affect reproductive success in birds and mammals which may affect population levels (Peakall, 1996). This can affect human welfare in several ways. If changes in populations reduces biological diversity in an area this may impact the total ecological system. To the extent that people value biological diversity (existence value), there may be benefits to preventing this loss. Also, hunters may experience direct losses if populations of game birds or animals are reduced. Hunters may also experience welfare losses if game birds or animals are not fit for consumption. Hunters may also be affected if predator populations are reduced from reduced availability of prey species. In addition to hunting, other non-consumptive uses of wildlife including bird or wildlife viewing may be impacted by reductions in bird and animal populations. In one special case, that of the endangered Florida panther, there may be special value placed on reducing the risks of species loss.

In general, HAP emission reductions achieved through the Industrial Boilers and Process Heaters NESHAP should reduce the associated adverse environmental impacts.

9.2.2 *Benefits of Reducing Other Pollutants Due to HAP Controls*

As is mentioned above, controls that will be required on boilers and process heaters to reduce HAPs will also reduce emissions of other pollutants, namely: PM_{10}, $PM_{2.5}$, and SO_2. According to baseline emission estimates, the source categories affected by this proposal currently emit approximately 766,000 tons per year of PM_{10}, 217,000 tons per year of $PM_{2.5}$, and 3,405,000 tons per year of SO_2 at existing sources. It is estimated that by the year 2005, new boilers and process heaters will emit 3,600 tons per year of PM_{10}, 1,000 tons of $PM_{2.5}$, and 38,200 tons of SO_2. This totals 769,600 tons of PM_{10}, 218,000 tons of $PM_{2.5}$, and 3,443,200 tons of SO_2 annually at all boiler and process heater sources. The regulation will reduce approximately 562,500 tons of PM_{10} emissions, 159,000 tons of $PM_{2.5}$, and 113,000 tons of SO_2 at new and existing sources by 2005. For more information on these HAP emissions and emission reductions, please refer to Chapter 8 of this RIA and the docket for this rule. The adverse effects from PM (both coarse and fine) and SO_2 emissions are presented below.

9.2.2.1 Benefits of Particulate Matter Reductions. Scientific studies have linked PM (alone or in combination with other air pollutants) with a series of health effects (EPA, 1996). Coarse (PM_{10}) particles can accumulate in the respiratory system and aggravate health problems such as asthma. Fine ($PM_{2.5}$) particles can penetrate deep into the lungs to contribute to a number of the health effects. These health effects include decreased lung function and alterations in lung tissue and structure and in respiratory tract defense mechanisms which may be manifest in increased respiratory symptoms and disease or in more severe cases, increased hospital admissions and emergency room visits or premature death. Children, the elderly, and people with cardiopulmonary disease, such as asthma, are most at risk from these health effects.

PM also causes a number of adverse effects on the environment. Fine PM is the major cause of reduced visibility in parts of the U.S., including many of our national parks and wilderness areas. Other environmental impacts occur when particles deposit onto soil, plants, water, or materials. For example, particles containing nitrogen and sulfur that deposit onto land or water bodies may change the nutrient balance and acidity of those environments, leading to changes in species composition and buffering capacity.

Particles that are deposited directly onto leaves of plants can, depending on their chemical composition, corrode leaf surfaces or interfere with plant metabolism. Finally, PM causes soiling and erosion damage to materials.

Thus, reducing the emissions of PM and PM precursors from boilers and process heater sources can help to improve some of the effects mentioned above - either those related to primary PM emissions, or the effects of secondary PM generated by the combination of SO_2 with other pollutants in the atmosphere.

9.2.2.2 Benefits of Sulfur Dioxide Reductions. Very high concentrations of sulfur dioxide (SO_2) affect breathing and ambient levels have been hypothesized to aggravate existing respiratory and cardiovascular disease. Potentially sensitive populations include asthmatics, individuals with bronchitis or emphysema, children and the elderly. SO_2 is also a primary contributor to acid deposition, or acid rain, which causes acidification of lakes and streams and can damage trees, crops, historic buildings and statues. In addition, sulfur compounds in the air contribute to visibility impairment in large parts of the country. This is especially noticeable in national parks.

PM can also be formed from SO_2 emissions. Secondary PM is formed in the atmosphere through a number of physical and chemical processes that transform gases, such as SO_2, into particles. Overall, emissions of SO_2 can lead to some of the effects discussed in this section - either those directly related to SO_2 emissions, or the effects of ozone and PM resulting from the combination of SO_2 with other pollutants.

9.3 Lack of Approved Methods to Quantify HAP Benefits

The most significant effect associated with the HAPs that are controlled with the rule is the potential incidence of cancer. In previous analyses of the benefits of reductions in HAPs, EPA has quantified and monetized the benefits of potential reductions in the incidences of cancer (EPA, 1992b, 1995). In some cases, EPA has also quantified (but not monetized) reductions in the number of people exposed to non-cancer HAP risks above no-effect levels (EPA, 1995).

Monetization of the benefits of reductions in cancer incidences requires several important inputs, including central estimates of cancer risks, estimates of exposure to carcinogenic HAPs, and estimates of the value of an avoided case of cancer (fatal and non-fatal). In the above referenced analyses, EPA relied on unit risk factors (URF) developed through risk assessment procedures. The unit risk factor is a quantitative estimate of the carcinogenic potency of a pollutant, often expressed as the probability of contracting cancer from a 70 year lifetime continuous exposure to a concentration of one $\mu g/m^3$ of a pollutant. These URFs are designed to be conservative, and as such, are more likely to represent the high end of the distribution of risk rather than a best or most likely estimate of risk.

In a typical analysis of the expected health benefits of a regulation (see for example the benefit analysis of the Interstate Air Quality Rule), health effects are estimated by applying changes in pollutant concentrations to best estimates of risk obtained from epidemiological studies. As the purpose of a benefit analysis is to describe the benefits most likely to occur from a reduction in pollution, use of high-end, conservative risk estimates over-estimate of the expected benefits of the regulation. For this reason, we will not attempt to quantify the health benefits of reductions in HAPs unless best estimates of risks are available. While we used high-end risk estimates in past analyses, recent advice from the EPA Science Advisory Board (SAB) and internal methods reviews have suggested that we avoid using high-end estimates in current analyses. EPA is working with the SAB to develop better methods for analyzing the benefits of reductions in HAPs.

While not appropriate as part of a primary estimate of benefits, to estimate the potential baseline risks posed by the industrial boiler and process heater source categories and the potential impact of applicability cutoffs discussed in Chapter 3 of this RIA, EPA performed a “rough” risk assessment, described below. There are large uncertainties regarding all components of the risk quantification step, including location of emission reductions, emission estimates, air concentrations, exposure levels and dose-response relationships. However, if these uncertainties are properly identified and characterized, it is possible to provide upper-bound estimates of the potential reduction in inhalation cancer incidence associated with this rule. It is important to keep in mind that these estimates will not cover non-inhalation based cancer risks and non-cancer health effects.

To estimate the potential baseline risks posed by the industrial boiler and process heater source categories, EPA performed a crude risk analysis of the industrial boiler and process heater source categories that focused only on cancer risks. The results of the analysis are based on approaches for estimating cancer incidence that carry significant assumptions, uncertainties, and limitations. Based on the assessment, if this proposed rule is implemented at all affected facilities, annual cancer incidence is estimated to be reduced on the order of tens of cases/year. Due to the uncertainties associated with the analysis, annual cancer incidence could be higher or lower than these estimates. (Details of this assessment are available in the docket.)

For non-cancer health effects, previous analyses have estimated changes in populations exposed above the reference concentration level (RfC). However, this requires estimates of populations exposed to HAPs from controlled sources. Due to data limitations, we do not have sufficient information on emissions from specific sources and thus are unable to model changes in population exposures to ambient concentrations of HAPs above the RfC. As a result, we are unable to place a monetary value of the HAP benefits associated with this rule.

9.4 Summary

The HAPs that are reduced as a result of implementing the Industrial Boilers and Process Heaters NESHAP will produce a variety of benefits, some of which include: the reduction in the incidence of cancer to exposed populations, neurotoxicity, irritation, and crop or plant damage. The rule will also produce benefits associated with reductions in fine and coarse PM and SO_2 emissions. Exposure to PM (either directly or through secondary formation from SO_2) can lead to several health effects, including premature death and increased hospital admissions and emergency room visits, increased respiratory symptoms and disease, decreased lung function, and alterations in lung tissue and structure and in respiratory tract defense mechanisms. Children, the elderly, and people with cardiopulmonary disease, such as asthma, are most at risk from these health effects. It can also form a haze that reduces the visibility of scenic areas, can cause acidification of water bodies, and have other impacts on soil, plants, and materials. High concentrations of SO_2 affect breathing and may aggravate existing respiratory and cardiovascular disease, which is more likely to affect asthmatics, individuals with bronchitis or emphysema, children and the elderly. SO_2 is also a primary contributor to acid deposition, or acid rain, which causes acidification of lakes and streams and can damage trees, crops, historic buildings and statues. In addition, sulfur compounds in the air contribute to visibility impairment in large parts of the country. This is especially noticeable in national parks.

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10.0 QUANTIFIED BENEFITS

10.1 Results in Brief

In this section, we calculate monetary benefits for the reductions in ambient PM concentrations resulting from the emission reductions described in Chapters 3 and 9. Benefits related to PM_{10} and $PM_{2.5}$ reductions are calculated using a combination of two approaches: (1) a direct valuation based on air quality analysis of modeled PM and SO_2 reductions at specific industrial boilers/process heaters, and (2) a benefits transfer approach which uses dollar per ton values generated from the air quality analysis completed in the first approach to value reductions from non-specific sources. Incremental benefits (in 1999 dollars) from boilers and process heater PM and SO_2 emission reductions are approximately $16 billion for the MACT floor. We also evaluated an above the floor regulatory option that is more stringent than final rule's MACT floor. Total annual benefits of the above the floor option are $17 billion. Although the benefits of the more stringent option are greater than the MACT floor, there are other costs and economic impacts that deem it an inferior regulatory option. Thus, the final rule is based on the selection of the MACT floor.

This benefits analysis does not quantify all potential benefits or disbenefits associated with PM and SO_2 reductions. This analysis also does not quantify the benefits associated with reductions in hazardous air pollutants (HAP). The magnitude of the unquantified benefits associated with omitted categories and pollutants, such as avoided cancer cases, damage to ecosystems, or materials damage to industrial equipment and national monuments, is not known. However, to the extent that unquantified benefits exceed unquantified disbenefits, the estimated benefits presented above will be an underestimate of actual benefits. There are many other sources of uncertainty in the estimates of quantified benefits. These sources of uncertainty, along with the methods for estimating monetized benefits for this NESHAP and a more detailed analysis of the results are presented below.

Table 10-1. Summary of Results: Estimated PM-Related Benefits of the Industrial Boilers and Process Heaters NESHAP

Estimation Method	Total Benefits[A, B] (millions 1999$)
MACT Floor:	
Using a 3% discount rate	$16 + B
Using a 7% discount rate	$15 + B
Above the MACT Floor:	
Using a 3% discount rate	$17 + B
Using a 7% discount rate	$16 + B

[A] Benefits of HAP emission reductions are not quantified in this analysis and, therefore, are not presented in this table. The quantifiable benefits are from emission reductions of SO_2 and PM only. For notational purposes, unquantified benefits are indicated with a "B" to represent additional monetary benefits. A detailed listing of unquantified SO_2, PM , and HAP related health effects is provided in Table 10-13.

[B] Results reflect the use of two different discount rates; a 3% rate which is recommended by EPA's Guidelines for Preparing Economic Analyses (US EPA, 2000a), and 7% which is recommended by OMB Circular A-94 (OMB, 1992).

10.2 Introduction

This chapter presents the methods used to estimate the monetary benefits of the reductions in PM and SO_2 emissions associated with control requirements resulting from the Industrial Boilers/Process Heaters NESHAP. Results are presented for the emission controls described in Chapter 3. The benefits that result from the rule include both the primary impacts from application of control technologies or changes in operations and processes, and the secondary effects of the controls. The regulation induced reductions in PM and SO_2 emissions also described in Chapter 3 will result in changes in the physical damages associated with exposure to elevated ambient concentrations of PM. These damages include changes in both human health and welfare effects categories. Benefits are calculated for the nation as a whole, assuming that controls are implemented at major sources (sources emitting > 10 tons of a HAP annual, or >25 tons of two or more HAPs annually).

The remainder of this chapter provides the following:

- Subsection 3 provides an overview of the benefits methodology.
- Subsection 4 discusses Phase One of the analysis: modeled air quality change and health effects resulting from a portion of emission reductions at a subset of boiler and process heaters sources
- Subsection 5 discusses Phase Two of the analysis: Benefit transfer valuation of remaining emission reductions

- Subsection 6 discusses total benefit estimated by combining the results of Phases 1 and 2.
- Subsection 7 discusses potential benefit categories that are not quantified due to data and/or methodological limitations, and provides a list of analytical uncertainties, limitations, and biases.

10.3 Overview of Benefits Analysis Methodology

This section documents the general approach used to estimate benefits resulting from emissions reductions from boiler and process heater sources. We follow the basic methodology described in the Regulatory Impact Analysis of the Heavy Duty Engine/Diesel Fuel rule [hereafter referred to as the HDD RIA] (US EPA, 2000), as well as discussions provided in the Proposed Non-Road Diesel Engines rule (NRD rule) and the Integrated Air Quality Rule (IAQR).

Since proposal of the Industrial Boilers and Process Heaters NESHAP, the benefit methodology utilized by EPA has been updated to reflect the current science in air quality modeling and benefits modeling. EPA has carefully considered the differences in methodology from proposal. Based on the IAQR benefit analysis document, we determined that the NESHAP's analysis from proposal does not include additional benefit endpoints (i.e., infant mortality, heart attacks, and asthma exacerbation), which would increase the total benefit estimate from proposal. The IAQR also uses a newer study of premature mortality due to PM, which would increase the benefit estimate from proposal. The VSL estimate for premature mortality has been lowered slightly from $6 million to $5.5 million in the IAQR, which would decrease the benefit estimate from proposal. Finally, an updated air quality model (i.e., REMSAD) would also increase our total benefit estimate in this analysis. Although the overall impact on total benefits is not determinable without a full reassessement of benefits, it is unlikely that our comparison of benefits to costs would not reveal a substantially different conclusion (e.g., we still expect benefits to exceed costs by a substantial amount). Therefore, we did not update the benefit analysis from proposal as it would not impact the benefit-cost comparison for this rule.

On September 26, 2002, the National Academy of Sciences (NAS) released a report on its review of the Agency's methodology for analyzing the health benefits of measures taken to reduce air pollution. The report focused on EPA's approach for estimating the health benefits of regulations designed to reduce concentrations of airborne particulate matter (PM).

In its report, the NAS said that EPA has generally used a reasonable framework for analyzing the health benefits of PM-control measures. It recommended, however, that the Agency take a number of steps to improve its benefits analysis. In particular, the NAS stated that the Agency should:

- include benefits estimates for a range of regulatory options;
- estimate benefits for intervals, such as every five years, rather than a single year;
- clearly state the project baseline statistics used in estimating health benefits,

including those for air emissions, air quality, and health outcomes;

- examine whether implementation of proposed regulations might cause unintended impacts on human health or the environment;
- when appropriate, use data from non-US studies to broaden age ranges to which current estimates apply and to include more types of relevant health outcomes;
- begin to move the assessment of uncertainties from its ancillary analyses into its primary analyses by conducting probabilistic, multiple-source uncertainty analyses. This assessment should be based on available data and expert judgment.

Although the NAS made a number of recommendations for improvement in EPA's approach, it found that the studies selected by EPA for use in its benefits analysis were generally reasonable choices. In particular, the NAS agreed with EPA's decision to use cohort studies to derive benefits estimates. It also concluded that the Agency's selection of the American Cancer Society (ACS) study for the evaluation of PM-related premature mortality was reasonable, although it noted the publication of new cohort studies that should be evaluated by the Agency.

Several of the NAS recommendations addressed the issue of uncertainty and how the Agency can better analyze and communicate the uncertainties associated with its benefits assessments. In particular, the Committee expressed concern about the Agency's reliance on a single value from its analysis and suggested that EPA develop a probabilistic approach for analyzing the health benefits of proposed regulatory actions. The Agency agrees with this suggestion and is working to develop such an approach for use in future rulemakings. In particular, the EPA is currently in the process of developing a comprehensive integrated strategy for characterizing the impact of uncertainty in key elements of the benefits modeling process (e.g., emissions modeling, air quality modeling, health effects incidence estimation, valuation) on the results that are generated. A subset of this effort, which is currently underway, involves an expert elicitation designed to characterize uncertainty in the estimation of PM-related mortality resulting from both short-term and longer-term exposure. The EPA will be evaluating the results of this elicitation to determine its usefulness in characterizing uncertainty in our estimates of PM-related mortality benefits. As elements of this uncertainty analysis strategy are finalized, it may be possible to integrate them into later iterations of regulatory analyses.

In this RIA at proposal, the Agency used an interim approach for characterizing uncertainty that showed the impact of several important alternative assumptions about the estimation and valuation of reductions in premature mortality and chronic bronchitis. This approach provided an alternative estimate of health benefits using the time series studies in place of cohort studies, as well as alternative valuation methods for mortality and chronic bronchitis risk reductions. However, reflecting comments from the SAB-HES as well as the NAS panel, rather than including an alternative estimate in the final rule, the EPA will continue to investigate the impact of key assumptions on mortality and morbidity estimates.

The analysis of benefits of this NESHAP is conducted in two phases. For a portion of the emission reductions expected from this rule, the first phase of analysis models the change in air quality and health effects around specific boiler and process heater sources. The benefits resulting from the changes in air quality are then quantified and monetized. For the remaining set of emission reductions, the specific location of the emission reduction is unknown due to limitations in the data. Therefore, the second phase of our benefits analysis is based on benefits transfer of the modeled changes in air quality and health effects from the location specific emissions reductions achieved in phase one of the analysis. More specifically, the benefit value per ton of emission reduction estimated in phase one is transferred and applied to the emission reductions in phase two of the analysis. Table 10-2 summarizes the emissions reductions associated with the phase one and phase two analyses. This table shows the emission reduction expected from two regulatory options considered for this rulemaking: the MACT floor, and an above the floor regulatory option. Although the NESHAP is expected to result in reductions in emissions of many HAPs as well as PM and SO_2, benefits transfer values are generated for only PM and SO_2 due to limitations in availability of transfer values, concentration-response functions, or air quality and exposure models for HAPs. For this analysis, we focus on directly emitted PM, and SO_2 in its role as a precursor in the formation of ambient particulate matter. Other potential impacts of PM and SO_2 reductions not quantified in this analysis, as well as potential impacts of HAPs reductions are described in Chapter 9.

Table 10-2.

Estimate of Emission Reductions for Phases One and Two of the Benefit Analysis

Regulatory Option	Total Emission Reductions (tons/yr)	Phase One: Modeled Emission Reductions (tons/yr)	Phase Two: Reductions Applied to Benefit Transfer Values
MACT Floor:			
SO_2	112,936	82,542	30,394
PM_{10}	562,110	265,115	296,955
$PM_{2.5}$	159,196	75,095	84,101
Above MACT Floor:			
SO_2	136,733	95,361	41,372
PM_{10}	569,229	313,947	255,282
$PM_{2.5}$	171,459	94,565	76,894

The general term "benefits" refers to any and all outcomes of the regulation that contribute to an enhanced level of social welfare. In this case, the term "benefits" refers to the dollar value associated with all the expected positive impacts of the regulation, that is, all regulatory outcomes that lead to higher social welfare. If the benefits are associated with market goods and services, the monetary value of the benefits is approximated by the sum of the predicted changes in consumer (and producer) "surplus." These "surplus" measures are standard and widely accepted measures in the field of applied welfare economics, and reflect the degree of well-being enjoyed by people given different levels of goods and prices. If the benefits are non-market benefits (such as the risk reductions associated with environmental quality improvements), however, other methods of measuring benefits must be used. In contrast to market goods, non-market goods such as environmental quality improvements are public goods, whose benefits are shared by many people. The total value of such a good is the sum of the dollar amounts that all those who benefit are willing to pay.

We follow a "damage-function" approach in calculating total benefits of the modeled changes in environmental quality. This approach estimates changes in individual health and welfare endpoints (specific effects that can be associated with changes in air quality) and assigns values to those changes assuming independence of the individual values. Total benefits are calculated simply as the sum of the values for all non-overlapping health and welfare endpoints. This imposes no overall preference structure, and does not account for potential income or substitution effects, i.e. adding a new endpoint will not reduce the value of changes in other endpoints. The "damage-function" approach is the standard approach for most cost-benefit analyses of regulations affecting environmental quality, and it has been used in several recent published analyses (Banzhaf et al., 2002; Levy et al, 2001; Kunzli et al, 2000; Levy et al, 1999; Ostro and Chestnut, 1998). Time and resource constraints prevented us from performing extensive new research to measure either the health outcomes or their values for this analysis. Thus, similar to these studies, our estimates are based on the best available methods of benefits transfer. Benefits transfer is the science and art of adapting primary research from similar contexts to obtain the most accurate measure of benefits available for the environmental quality change under analysis.

10.3.1 *Methods for Estimating Benefits from Air Quality Improvements*

Environmental and health economists have a number of methods for estimating the economic value of improvements in (or deterioration of) environmental quality. The method used in any given situation depends on the nature of the effect and the kinds of data, time, and resources that are available for investigation and analysis. This section provides an overview of the methods we selected to monetize the benefits included in this RIA.

We note at the outset that EPA rarely has the time or resources to perform extensive new research in the form of evaluating the response in human health effects from specific changes in the concentration of pollutants, or by issuing surveys to collect data of individual's willingness to pay for a particular rule's given change in air quality, which is needed to fully measure the economic benefits of individual rulemakings. As a result, our estimates are based on the best available methods of benefit transfer from epidemiological studies and studies of the economic value of reducing certain health and welfare effects. Benefit transfer is the science and art of adapting primary benefits research on concentration-response functions and measures of the value individuals place on an improvement in a given health effect to the scenarios evaluated for a particular regulation. Thus, we strive to obtain the most accurate measure of benefits for the environmental quality change under analysis given availability of current, peer reviewed research and literature.

In general, economists tend to view an individual's willingness-to-pay (WTP) for an improvement in environmental quality as the most complete and appropriate measure of the value of an environmental or health risk reduction. An individual's willingness-to-accept (WTA) compensation for not receiving the improvement is also a valid measure. Willingness to pay and Willingness to accept are comparable measures when the change in environmental quality is small and there are reasonably close substitutes available. However, WTP is generally considered to be a more readily available and conservative measure of benefits.

Adoption of WTP as the measure of value implies that the value of environmental quality improvements is dependent on the individual preferences of the affected population and that the existing distribution of income (ability to pay) is appropriate.

For many goods, WTP can be observed by examining actual market transactions. For example, if a gallon of bottled drinking water sells for one dollar, it can be observed that at least some persons are willing to pay one dollar for such water. For goods not exchanged in the market, such as most environmental "goods," valuation is not as straightforward. Nevertheless, a value may be inferred from observed behavior, such as sales and prices of products that result in similar effects or risk reductions, (e.g., non-toxic cleaners or bike helmets). Alternatively, surveys may be used in an attempt to directly elicit WTP for an environmental improvement.

One distinction in environmental benefits estimation is between "use values"and "non-use values." Although no general agreement exists among economists on a precise distinction between the two, the general nature of the difference is clear. Use values are those aspects of environmental quality that affect an individual's welfare more or less directly. These effects include changes in product prices, quality, and availability, changes in the quality of outdoor recreation and outdoor aesthetics, changes in health or life expectancy, and the costs of actions taken to avoid negative effects of environmental quality changes.

Non-use values are those for which an individual is willing to pay for reasons that do not relate to the direct use or enjoyment of any environmental benefit, but might relate to existence values and bequest values. Non-use values are not traded, directly or indirectly, in markets. For this reason, the measurement of non-use values has proved to be significantly more difficult than the measurement of use values. The air quality changes produced by this NESHAP cause changes in both use and non-use values, but the monetary benefit estimates are almost exclusively for use values.

More frequently than not, the economic benefits from environmental quality changes are not traded in markets, so direct measurement techniques can not be used. Avoided cost methods are ways to estimate the costs of pollution by using the expenditures made necessary by pollution damage. For example, if buildings must be cleaned or painted more frequently as levels of PM increase, then the appropriately calculated increment of these costs is a reasonable lower bound estimate (under most conditions) of true economic benefits when PM levels are reduced. Avoided costs methods are used to estimate some of the health-related benefits related to morbidity, such as hospital admissions (see the NRD rule and the IAQR for a detailed discussion of methods to value benefit categories).

Indirect market methods can also be used to infer the benefits of pollution reduction. The most important application of this technique for our analysis is the calculation of the value of a statistical life for use in the estimate of benefits from mortality reductions. There exists no market where changes in the probability of death are directly exchanged. However, people make decisions about occupation, precautionary behavior, and other activities associated with changes in the risk of death. By examining these risk changes and the other characteristics of people's choices, it is possible to infer information about the monetary values associated with changes in mortality risk (see Section 10.4). For measurement of health benefits, this analysis captures the WTP for most use and non-use values, with the exception of the value of avoided hospital admissions, which only captures the avoided cost of illness because no WTP values were available in the published literature.

10.3.2 *Methods for Describing Uncertainty*

In any complex analysis using estimated parameters and inputs from numerous models, there are likely to be many sources of uncertainty.[16] This analysis is no exception. As outlined both in this and preceding chapters, there are many inputs used to derive the final estimate of benefits, including emission inventories, air quality models (with their associated parameters and inputs), epidemiological estimates of concentration-response (C-R) functions, estimates of values (both from WTP and cost-of-illness studies), population estimates, income estimates, and estimates of the future state of the world (i.e., regulations, technology, and human behavior). Each of these inputs may be uncertain, and depending on their location in the benefits analysis, may have a disproportionately large impact on final estimates of total benefits. For example, emissions estimates are used in the first stage of the analysis. As such, any uncertainty in emissions estimates will be propagated through the entire analysis. When compounded with uncertainty in later stages, small uncertainties in emission levels can lead to much larger impacts on total benefits.

Some key sources of uncertainty in each stage of the benefits analysis are:

- Gaps in scientific data and inquiry;
- Variability in estimated relationships, such as C-R functions, introduced through differences in study design and statistical modeling;
- Errors in measurement and projection for variables such as population growth rates;
- Errors due to mis-specification of model structures, including the use of surrogate variables, such as using PM_{10} when $PM_{2.5}$ is not available, excluded variables, and simplification of complex functions; and
- Biases due to omissions or other research limitations.

Some of the key uncertainties in the benefits analysis are presented in Table 10-3. Several of the methods employed in this analysis are similar to the methods employed in the Heavy Duty Diesel and Fuel Standard (HDD TSD). Information on the uncertainty surrounding particular C-R and valuation functions is provided in the HDD TSD, and have been updated in the TSD for the benefits of the Proposed Non-Road Diesel Engines rule (NRD rule) (EPA, 2003a), and in the documentation for the Integrated Air Quality Rule (IAQR) (EPA, 2003b).

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[16] It should be recognized that in addition to uncertainty, the annual benefit estimates for the Industrial Boilers/Process Heaters NESHAP presented in this analysis are also inherently variable, due to the truly random processes that govern pollutant emissions and ambient air quality in a given year. Factors such as electricity demand and weather display constant variability regardless of our ability to accurately measure them. As such, the estimates of annual benefits should be viewed as representative of the types of benefits that will be realized, rather than the actual benefits that would occur every year.

Our estimated range of total benefits should be viewed as an approximate result because of the sources of uncertainty discussed above (see Table 10-3). The total benefits estimate may understate or overstate actual benefits of the rule.

In considering the monetized benefits estimates, the reader should remain aware of the many limitations of conducting these analyses mentioned throughout this RIA. One significant limitation of both the health and welfare benefits analyses is the inability to quantify many of the serious effects discussed in Chapter 9.

In particular, there are significant categories of PM-related benefits that cannot be monetized (or in many cases even quantified), and thus they are not included in our accounting of health and welfare benefits. These unquantified effects include low birth weight, changes in pulmonary function, chronic respiratory diseases other than chronic bronchitis, morphological changes, altered host defense mechanisms, non-fatal cancers, and non-asthma respiratory emergency room visits. A complete discussion of PM related health effects can be found in the PM Criteria Document (U.S. EPA, 1996). In general, if it were possible to monetize these benefits categories, the benefits estimates presented in this analysis would increase. Unquantified benefits are qualitatively discussed in the in Chapter 9 and presented in Table 10-16. The net effect of excluding benefit and disbenefit categories from the estimate of total benefits depends on the relative magnitude of the effects.

In addition, when we proposed the Industrial Boilers and Process Heaters NESHAP in 2003, we also included an alternative estimate of benefits in addition to a base estimate that was intended to evaluate the impact of several key assumptions on the estimated reductions in premature mortality and CB. However, reflecting comments from the SAB-HES as well as the NAS panel, we do not present an alternative estimate to reflect uncertainty in our benefit estimate. To better understand the scope of potential uncertainties, in several upcoming analyses EPA will investigate the impact of key assumptions on mortality and morbidity estimates through a series of sensitivity analyses.

The benefits estimates generated for the final rule are subject to a number of assumptions and uncertainties, which are discussed throughout the document. For example, key assumptions underlying the primary estimate for the mortality category include the following:

(1) Inhalation of fine particles is causally associated with premature death at concentrations near those experienced by most Americans on a daily basis. Although biological mechanisms for this effect have not yet been definitively established, the weight of the available epidemiological evidence supports an assumption of causality.

(2) All fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because PM produced via transported precursors emitted from EGUs may differ significantly from direct PM released from automotive engines and other industrial sources, but no clear scientific grounds exist for supporting differential effects estimates by particle type.

(3) The C-R function for fine particles is approximately linear within the range of ambient concentrations under consideration. Thus, the estimates include health benefits from reducing fine particles in areas with varied concentrations of PM, including both regions that are in attainment with fine

particle standard and those that do not meet the standard.

(4) The forecasts for future emissions and associated air quality modeling are valid. Although recognizing the difficulties, assumptions, and inherent uncertainties in the overall enterprise, these analyses are based on peer-reviewed scientific literature and up-to-date assessment tools, and we believe the results are highly useful in assessing this proposal.

Table 10-3. Primary Sources of Uncertainty in the Source Benefit Analyses

1. Uncertainties Associated With Health Impact Functions
– The value of the PM effect estimate in each impact function. – Application of a single effect estimate to pollutant changes and populations in all locations. – Similarity of future year effect estimates to current effect estimates. – Correct functional form of each impact function. – Application of effect estimates to changes in PM outside the range of PM concentrations observed in the study. – Application of effect estimates only to those subpopulations matching the original study population.
2. Uncertainties Associated With PM Concentrations
– Responsiveness of the models to changes in precursor emissions. – Projections of future levels of precursor emissions, especially ammonia and crustal materials. – Model chemistry for the formation of ambient nitrate concentrations. – Use of separate air quality models for ozone and PM does not allow for a fully integrated analysis of pollutants and their interactions.
3. Uncertainties Associated with PM Mortality Risk
– Limited scientific literature supporting a direct biological mechanism for observed epidemiological evidence. – Direct causal agents within the complex mixture of PM have not been identified. – The extent to which adverse health effects are associated with low level exposures that occur many times in the year versus peak exposures. – The extent to which effects reported in the long-term exposure studies are associated with historically higher levels of PM rather than the levels occurring during the period of study. – Reliability of the limited ambient $PM_{2.5}$ monitoring data in reflecting actual $PM_{2.5}$ exposures.
4. Uncertainties Associated With Possible Lagged Effects
– The portion of the PM-related long-term exposure mortality effects associated with changes in annual PM levels would occur in a single year is uncertain as well as the portion that might occur in subsequent years.
5. Uncertainties Associated With Baseline Incidence Rates
– Some baseline incidence rates are not location-specific (e.g., those taken from studies) and may therefore not accurately represent the actual location-specific rates. – Current baseline incidence rates may not approximate well baseline incidence rates in 2010. – Projected population and demographics may not represent well future-year population and demographics.
6. Uncertainties Associated With Economic Valuation
– Unit dollar values associated with health endpoints are only estimates of mean WTP and therefore have uncertainty surrounding them. – Mean WTP (in constant dollars) for each type of risk reduction may differ from current estimates due to differences in income or other factors.
7. Uncertainties Associated With Aggregation of Monetized Benefits
– Health benefits estimates are limited to the available effect estimates. Thus, unquantified or unmonetized benefits are not included.

10.4 Phase One Analysis: Modeled Air Quality Change and Health Effects Resulting from a Portion of Emission Reductions at Boiler and Process Heaters Sources

In phase one of the benefit analysis, we are able to link approximately 50 percent of the emission reductions from this regulation to specific locations of boilers/process heaters. This allows us to evaluate the change in air quality around these sources and the resulting effect on the health of the surrounding population. The analysis performed for the emission reductions evaluated in phase one can be thought of as having three parts, including:

1. Calculation of the impact that our standards will have on the nationwide inventories for PM and SO_2 emissions;

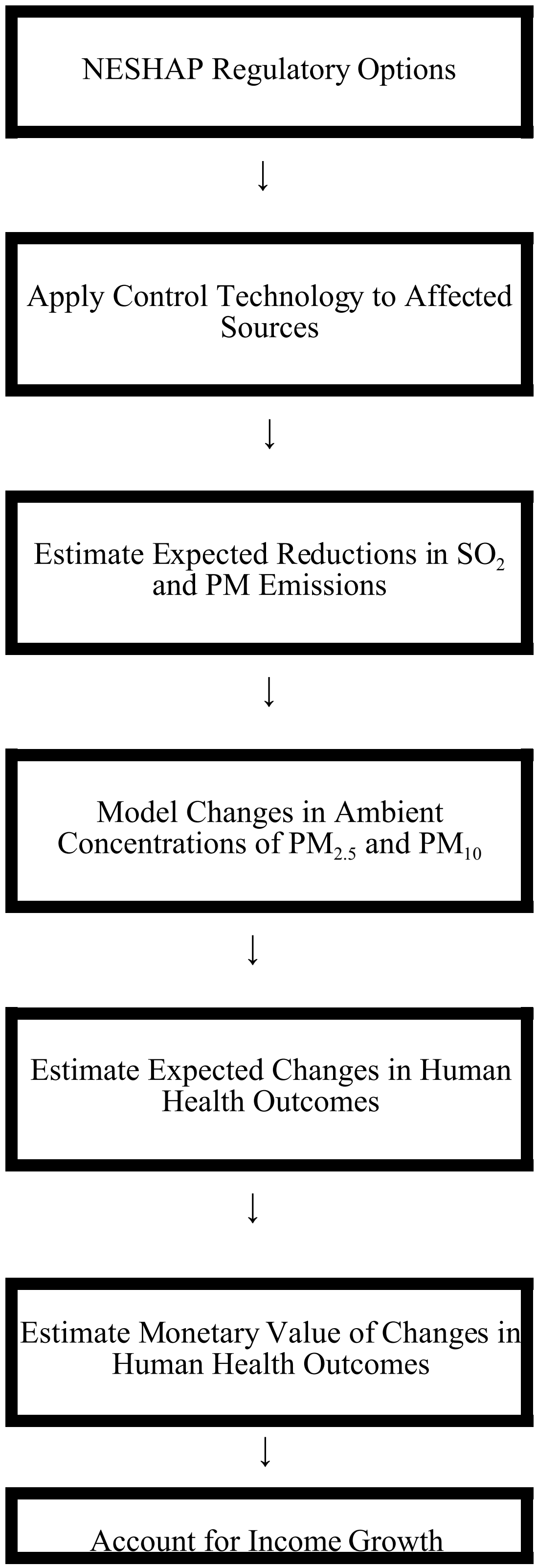
2. Air quality modeling to determine the changes in ambient concentrations of PM that will result from the changes in nationwide inventories of directly emitted PM and precursor pollutants; and

3. A benefits analysis to determine the changes in human health, both in terms of physical effects and monetary value, that result from the changes in ambient concentrations of PM.

Steps 1 and 2 are discussed in previous chapters of this RIA. For step 3, we follow the same general methodology used in the benefits analysis of the HDD rulemaking, as well as the proposed NRD rule and the IAQR. EPA also relies heavily on the advice of its independent Science Advisory Board (SAB) in determining the health and welfare effects considered in the benefits analysis and in establishing the most scientifically valid measurement and valuation techniques.

Figure 10-1 illustrates the steps necessary to link the emission reductions included in the phase one analysis with economic measures of benefits. The first two steps involve the specification and implementation of the regulation. First, the specific regulatory options for reducing air pollution from industrial boilers/process heaters are established. In this chapter, we evaluate the benefits of two regulatory options: the MACT floor and an above the floor option. Next, we determine the changes in boiler and process heater control technology that can be used to meet the level of emissions reductions specified by the regulatory options (see Chapter 2). The changes in pollutant emissions resulting from the required changes in control technology at boilers/process heaters are then calculated, along with predictions of emissions for other industrial sectors in the baseline. The predicted emissions reductions described in Chapter 3 are then used as inputs to air quality models that predict ambient concentrations of pollutants over time and space. These concentrations depend on climatic conditions and complex chemical interactions.

Figure 10-1. Steps in Phase One of the Benefits Analysis for the Industrial Boilers/Process Heaters NESHAP



and Calculate Total Benefits

Changes in ambient concentrations will lead to new levels of environmental quality in the U.S., reflected both in human health and in non-health welfare effects. For this analysis, however, we do not evaluate and monetize changes in non-health welfare effects, such as visibility and agricultural yields. To generate estimated health outcomes, projected changes in ambient PM concentrations were input to a benefits model, known as the Criteria Air Pollutant Modeling System (CAPMS), a customized GIS-based program. CAPMS assigns pollutant concentrations to population grid cells for input into concentration-response functions. CAPMS uses census block population data and changes in pollutant concentrations to estimate changes in health outcomes for each grid cell. For purposes of this analysis, we assume a constant proportion of baseline incidence of the various health effects to the future incidence of health effects.

Our analysis also accounts for expected growth in real income over time. Economic theory argues that WTP for most goods (such as environmental protection) will increase if real incomes increase. The economics literature suggests that the severity of a health effect is a primary determinant of the strength of the relationship between changes in real income and WTP (Alberini, 1997; Miller, 2000; Viscusi, 1993). As such, we use different factors to adjust the WTP for minor health effects, severe and chronic health effects, and premature mortality. Adjustment factors used to account for projected growth in real income from 1990 to 2005 are 1.03 for minor health effects, 1.09 for severe and chronic health effects, and 1.08 for premature mortality[17].

It should be noted that since proposal of the Industrial Boilers and Process Heaters NESHAP, the benefit methodology utilized by EPA has been updated to reflect the current science in air quality modeling and benefits modeling. Due to time and resource constraints, EPA was unable to complete a full reassessment of the benefits analysis from proposal. However, EPA has carefully considered the differences in methodology from proposal. Based on the IAQR benefit analysis document, we determined that the NESHAP's analysis from proposal does not include additional benefit endpoints (i.e., infant mortality, heart attacks, and asthma exacerbation), which would increase the total benefit estimate from proposal. The IAQR also uses a newer study of premature mortality due to PM, which would increase the benefit estimate from proposal. The VSL estimate for premature mortality has been lowered slightly from $6 million to $5.5 million in the IAQR, which would decrease the benefit estimate from proposal. Finally, an updated air quality model (i.e., REMSAD) would also increase our total benefit estimate in this analysis. Although the overall impact on total benefits is not determinable without a full reassessement of benefits, it is unlikely that our comparison of benefits to costs would reveal a substantially different conclusion (e.g., we still expect benefits to exceed costs by a substantial amount).

Based on the structure of analysis presented above, Section 10.4.1 provides a description of how we quantify and value changes in individual health effects. Then, in Section 10.4.2 we present quantified estimates of the reductions in health effects resulting

[17]Details of the calculation of the income adjustment factors are provided in the IAQR RIA (U.S. EPA, 2003b).

from phase one of the benefit analysis.

10.4.1 *Quantifying Individual Health Effect Endpoints*

We use the term "endpoints" to refer to specific effects that can be associated with changes in air quality. To estimate these endpoints, EPA combines changes in ambient air quality levels with epidemiological evidence about population health response to pollution exposure. The most significant monetized benefits of reducing ambient concentrations of PM are attributable to reductions in human health risks. EPA's Criteria Document for PM lists numerous health effects known to be linked to ambient concentrations of the pollutant (US EPA, 1996a). The previous chapter described some of these effects. This section describes methods used to quantify and monetize changes in the expected number of incidences of various health effects. For further detail on the methodology used to assess human health benefits such as those included in phase one of this analysis, refer to the HDD RIA and TSD, and the IAQR benefit analysis.

The specific PM endpoints that are evaluated in this analysis include:

- Premature mortality
- Bronchitis - chronic and acute
- Hospital admissions - respiratory and cardiovascular
- Emergency room visits for asthma
- Asthma attacks
- Lower and upper respiratory illness
- Minor restricted activity days
- Work loss days

As is discussed previously, this analysis relies on concentration-response (C-R) functions estimated in published epidemiological studies relating health effects to ambient air quality. The specific studies from which C-R functions are drawn are included in Table 10-4. Because we rely on methodology used in prior benefit analyses, a complete discussion of the C-R functions used for this analysis and information about each endpoint are contained in the IAQR RIA .

While a broad range of serious health effects have been associated with exposure to elevated PM levels (described more fully in the EPA's PM Criteria Document (US EPA, 1996a), we include only a subset of health effects in this quantified benefit analysis. Health effects are excluded from this analysis for four reasons: (i) the possibility of double counting (such as hospital admissions for specific respiratory diseases); (ii) uncertainties in applying effect relationships based on clinical studies to the affected population; (iii) a lack of an established C-R relationship; or (iv) lack of resources to estimate some endpoints.

Using the C-R functions derived from the studies cited in this table, we apply that same C-R relationship to all locations in the U.S. Although the C-R relationship may in fact vary somewhat from one location to another (for example, due to differences in population susceptibilities or differences in the composition of PM), location-specific C-R functions are generally not available. A single function applied everywhere may result in overestimates of incidence changes in some locations and underestimates in other locations, but these location-specific biases will, to some extent, cancel each other out when the total incidence change is calculated. It is not possible to know the extent or direction of the bias in the total incidence change based on the general application of a single C-R function everywhere.

Recently, the Health Effects Institute (HEI) reported findings by investigators at Johns Hopkins University and others that have raised concerns about aspects of the statistical methodology used in a number of recent time-series studies of short-term exposures to air pollution and health effects (Greenbaum, 2002a). Some of the concentration-response functions used in this benefits analysis were derived from such short-term studies. The estimates derived from the long-term mortality studies, which account for a major share of the benefits in theanalysis, are not affected. As discussed in HEI materials provided to sponsors and to the Clean Air Scientific Advisory Committee (Greenbaum, 2002a, 2002b), these investigators found problems in the default "convergence criteria" used in Generalized Additive Models (GAM) and a separate issue first identified by Canadian investigators about the potential to underestimate standard errors in the same statistical package.[1] These and other investigators have begun to reanalyze the results of several important time series studies with alternative approaches that address these issues and have found a downward revision of some results. For example, the mortality risk estimates for short-term exposure to PM_{10} from NMMAPS were overestimated (the C-R function based on the NMMAPS results used in this benefits analysis uses the revised NMMAPS results).[2] However, both the relative magnitude and the direction of bias introduced by the convergence issue is case-specific. In most cases, the concentration-response relationship may be overestimated; in other cases, it may be underestimated. The preliminary renalyses of the mortality and morbidity components of NMMAPS suggest that analyses reporting the lowest relative risks appear to be affected more greatly by this error than studies reporting higher relative risks (Dominici et al., 2002; Schwartz and Zanobetti, 2002).

Our examination of the original studies used in this analysis finds that the health endpoints that are potentially affected by the GAM issues include: reduced hospital admissions and reduced lower respiratory symptoms; reduced lower respiratory symptoms; and reduced premature mortality due to short-term PM_{10} exposures and reduced premature mortality due to short-term $PM_{2.5}$ exposures. While resolution of these issues is likely to take some time, the preliminary results from ongoing reanalyses of some of the studies used in our analyses (Dominici et al, 2002; Schwartz and Zanobetti, 2002; Schwartz, personal communication 2002) suggest a more modest effect of the S-plus error than reported for the NMMAPS PM_{10} mortality study. While we wait for further clarification from the scientific community, we have chosen not to remove these results from the Industrial Boilers and Process Heaters NESHAP benefits estimates, nor have we elected to apply any interim adjustment factor based on the preliminary reanalyses. EPA will continue to monitor the progress of this concern, and make appropriate adjustments as further information is made available.

10.4.1.1 Concentration-Response Functions for Premature Mortality

Both long and short-term exposures to ambient levels of air pollution have been associated with increased risk of premature mortality. The size of the mortality risk estimates from these epidemiological studies, the serious nature of the effect itself, and the high monetary value ascribed to prolonging life make mortality risk reduction the most important health endpoint quantified in this analysis. Because of the importance of this endpoint and the considerable uncertainty among economists and policymakers as to the appropriate way to value reductions in mortality risks, this section discusses some of the issues surrounding the estimation of premature mortality. For additional discussion on mortality and issues related to estimating risk for other health effects categories, we refer readers to the discussions presented in the IAQR.

Epidemiological analyses have consistently linked air pollution, especially PM, with excess mortality. Although a number of uncertainties remain to be addressed by continued research (NRC, 1998), a substantial body of published scientific literature documents the correlation between elevated PM concentrations and increased mortality rates. Community epidemiological studies that have used both short-term and long-term exposures and response have been used to estimate PM/ mortality relationships. Short-term studies use a time-series approach to relate short-term (often day-to-day) changes in PM concentrations and changes in daily mortality rates up to several days after a period of elevated PM concentrations. Long-term studies examine the potential relationship between community-level PM exposures over multiple years and community-level annual mortality rates.

Table 10-4. PM-related Health Outcomes and Studies Included in the Analysis

Health Outcome	Pollutant	Applied Population	Source of Effect Estimate	Source of Baseline Incidence
Premature Mortality				
All-cause premature mortality from long-term exposure	$PM_{2.5}$	> 29 years	Krewski et al., 2000	U.S. Centers for Disease Control, 1999
Chronic Illness				
Chronic Bronchitis (pooled estimate)	$PM_{2.5}$ PM_{10}	> 26 years > 29 years	Abbey et al., 1995 Schwartz et al., 1993	Abbey et al., 1993 Abbey et al., 1993 Adams and Marano, 1995
Hospital Admissions				
COPD	PM_{10}	> 64 years	Samet et al., 2000	Graves and Gillum, 1997
Pneumonia	PM_{10}	> 64 years	Samet et al., 2000	Graves and Gillum, 1997
Asthma	$PM_{2.5}$	< 65 years	Sheppard et al., 1999	Graves and Gillum, 1997
Total Cardiovascular	PM_{10}	> 64 years	Samet et al., 2000	Graves and Gillum, 1997
Asthma-Related ER Visits	PM_{10}	All ages	Schwartz et al., 1993	Smith et al., 1997 Graves and Gillum, 1997
Other Effects				
Asthma Attacks	PM_{10}	Asthmatics, all ages	Whittemore and Korn, 1980	Krupnick, 1988 Adams and Marano, 1995
Acute Bronchitis	$PM_{2.5}$	Children, 8-12 years	Dockery et al., 1996	Adams and Marano, 1995
Upper Respiratory Symptoms	PM_{10}	Asthmatic children, 9-11	Pope et al., 1991	Pope et al., 1991
Lower Respiratory Symptoms	$PM_{2.5}$	Children, 7-14 years	Schwartz et al., 1994	Schwartz et al., 1994
Work Loss Days	$PM_{2.5}$	Adults, 18-65 years	Ostro, 1987	Adams and Marano, 1995
Minor Restricted Activity Days (minus asthma attacks)	$PM_{2.5}$	Adults, 18-65 years	Ostro and Rothschild., 1989	Ostro and Rothschild, 1989

Researchers have found statistically significant associations between PM and premature mortality using both types of studies. In general, the risk estimates based on the long-term exposure studies are larger than those derived from short-term studies. Cohort analyses are better able to capture the full public health impact of exposure to air pollution over time (Kunzli, 2001; NRC, 2002). This section discusses some of the issues surrounding the estimation of premature mortality.

Over a dozen studies have found significant associations between various measures of long-term exposure to PM and elevated rates of annual mortality, beginning with Lave and Seskin (1977). Most of the published studies found positive (but not always statistically significant) associations with available PM indices such as total suspended particles (TSP). Particles of different fine particles components (i.e., sulfates), and fine particles, as well as exploration of alternative model specifications sometimes found inconsistencies (e.g., Lipfert, [1989]). These early “cross-sectional” studies (e.g., Lave and Seskin [1977]; Ozkaynak and Thurston [1987]) were criticized for a number of methodological limitations, particularly for inadequate control at the individual level for variables that are potentially important in causing mortality, such as wealth, smoking, and diet. More recently, several long-term studies have been published that use improved approaches and appear to be consistent with the earlier body of literature. These new “prospective cohort” studies reflect a significant improvement over the earlier work because they include individual-level information with respect to health status and residence. The most extensive study and analyses has been based on data from two prospective cohort groups, often referred to as the Harvard “Six-City Study” (Dockery et al., 1993) and the “American Cancer Society or ACS study” (Pope et al., 1995); these studies have found consistent relationships between fine particle indicators and premature mortality across multiple locations in the United States. A third major data set comes from the California based 7th Day Adventist Study (e.g., Abbey et al, 1999), which reported associations between long-term PM exposure and mortality in men. Results from this cohort, however, have been inconsistent and the air quality results are not geographically representative of most of the United States. More recently, a cohort of adult male veterans diagnosed with hypertension has been examined (Lipfert et al., 2000). The characteristics of this group differ from the cohorts in the ACS, Six-Cities, and 7th Day Adventist studies with respect to income, race, health status, and smoking status. Unlike previous long-term analyses, this study found some associations between mortality and ozone but found inconsistent results for PM indicators. Because of the selective nature of the population in the veteran’s cohort, which may have resulted in estimates of relative risk that are biased relative to a relative risk for the general population, we have chosen not to include any effect estimates from the Lipfert et al. (2000) study in our benefits assessment.[18]

Given their consistent results and broad geographic coverage, the Six-City and ACS data have been particularly important in benefits analyses. The credibility of these two studies is

[18]The EPA recognizes that the ACS cohort also is not completely representative of the demographic mix in the general population. The ACS cohort is almost entirely white, and has higher income and education levels relative to the general population. The EPA’s approach to this problem is to match populations based on the potential for demographic characteristics to modify the effect of air pollution on mortality risk. Thus, for the various ACS-based models, we are careful to apply the effect estimate only to ages matching those in the original studies, because age has a potentially large modifying impact on the effect estimate, especially when younger individuals are excluded from the study population. For the Lipfert analysis, the applied population should be limited to that matching the sample used in the analysis. This sample was all male, veterans, and diagnosed hypertensive. There are also a number of differences between the composition of the sample and the general population, including a higher percentage of African Americans (35 percent), and a much higher percentage of smokers (81 percent former smokers, 57 percent current smokers) than the general population (12 percent African American, 24 percent current smokers). These composition differences cannot be controlled for, but should be recognized as adding to the potential extrapolation bias. The EPA recognizes the difficulty in controlling for composition of income and education levels. However, in or out criterion such as age, veteran status, hypertension, race and sex are all controllable by applying filters to the population data. The EPA has traditionally only controlled for age, because the ACS study used only age as a screen.

further enhanced by the fact that they were subject to extensive reexamination and reanalysis by an independent team of scientific experts commissioned by HEI (Krewski et al., 2000). The final results of the reanalysis were then independently peer reviewed by a Special Panel of the HEI Health Review Committee. The results of these reanalyses confirmed and expanded those of the original investigators. This intensive independent reanalysis effort was occasioned both by the importance of the original findings as well as concerns that the underlying individual health effects information has never been made publicly available.

The HEI re-examination lends credibility to the original studies and highlights sensitivities concerning the relative impact of various pollutants, the potential role of education in mediating the association between pollution and mortality, and the influence of spatial correlation modeling. Further confirmation and extension of the overall findings using more recent air quality and a longer follow-up period for the ACS cohort was recently published in the *Journal of the American Medical Association* (Pope et al., 2002).

In developing and improving the methods for estimating and valuing the potential reductions in mortality risk over the years, the EPA has consulted with the SAB-HES. That panel recommended use of long-term prospective cohort studies in estimating mortality risk reduction (EPA-SAB-COUNCIL-ADV-99-005, 1999). This recommendation has been confirmed by a recent report from the National Research Council, which stated that "it is essential to use the cohort studies in benefits analysis to capture all important effects from air pollution exposure" (NAS, 2002, p. 108). More specifically, the SAB recommended emphasis on the ACS study because it includes a much larger sample size and longer exposure interval and covers more locations (e.g., 50 cities compared to the Six Cities Study) than other studies of its kind. As explained in the regulatory impact analysis for the Heavy-Duty Engine/Diesel Fuel rule (EPA, 2000a), more recent EPA benefits analyses have relied on an improved specification of the ACS cohort data that was developed in the HEI reanalysis (Krewski et al., 2000). The latest reanalysis of the ACS cohort data (Pope et al., 2002), provides additional refinements to the analysis of PM-related mortality by (a) extending the follow-up period for the ACS study subjects to 16 years, which triples the size of the mortality data set; (b) substantially increasing exposure data, including consideration for cohort exposure to PM2.5 following implementation of PM2.5 standard in 1999; (c) controlling for a variety of personal risk factors including occupational exposure and diet; and (d) using advanced statistical methods to evaluate specific issues that can adversely affect risk estimates including the possibility of spatial autocorrelation of survival times in communities located near each other. Because of these refinements, the SAB- HES recommends using the Pope et al. (2002) study as the basis for the primary mortality estimate for adults and suggests that alternate estimates of mortality generated using other cohort and time series studies could be included as part of the sensitivity analysis (SAB-HES, 2003). However, as is discussed above EPA did not reassess the benefit analysis presented at proposal of this rule to account for the new data of the Pope et al. (2002) study.

This analysis also accounts for a lag between reductions in PM 2.5 concentrations and reductions in mortality incidence. It is currently unknown whether there is a time lag (a delay between changes in PM exposures and changes in mortality rates) in the long-term PM2.5/premature mortality relationship. The existence of such a lag is important for the valuation of premature mortality incidences because economic theory suggests that benefits occurring in the future should be discounted. Although there is no specific scientific evidence of the existence or structure of a PM effects lag, current scientific literature on adverse health effects, such as those associated with PM (e.g., smoking-related disease) and the difference in the effect size between chronic exposure studies and daily mortality studies suggest that all incidences of premature mortality reduction associated with a given incremental change in PM exposure probably would not occur in the same year as the exposure reduction. This same smoking-related literature implies that lags of up to a few years are plausible. Adopting the lag structure endorsed by the SAB (EPA-SAB-COUNCIL-ADV-00-001, 1999), we assume a five-year lag structure, with 25 percent of premature deaths occurring in the first year (in 2005), another 25 percent in the second year, and 16.7 percent in each of the remaining three years. The mortality incidences across the 5-year period is then discounted back to our year of analysis, 2005.

For reductions in direct emissions of PM_{10}, we use a different C-R function, based on the studies of mortality and shorter term exposures to PM. Long-term studies of the relationship between chronic exposure and mortality have not found significant associations with coarse particles or total PM_{10}. As discussed earlier in this chapter, concerns have recently been raised about aspects of the statistical methodology used in a number of recent time-series studies of short-term exposures to air pollution and health effects. Due to the "S-Plus" issue identified by the Health Effects Institute, we use as the basis for the our primary estimate the revised relative risk from the NMMAPS study, reported on the website of the Johns Hopkins School of Public Health[19]. Similar to the $PM_{2.5}$ lag adjustment discussed above, we also include an adjustment for PM_{10} to account for recent evidence that daily mortality is associated with particle levels from a number of previous days. We use the overall pooled NMMAPS estimate of a 0.224 percent increase in mortality for a 10 μg/m3 increase in PM_{10} as the starting point in developing our C-R function. In a recent analysis, Schwartz (2000) found that elevated levels of PM_{10} on a given day can elevate mortality on a number of following days. This type of multi-day model is often referred to as a "distributed lag" model because it assumes that mortality following a PM event will be distributed over a number of days following or "lagging" the PM event[5]. Because the NMMAPS study reflects much broader geographic coverage (90 cities) than the Schwartz study (10 cities), and the Schwartz study has not been reanalyzed to account for the "S-Plus" issue, we choose to apply an adjustment based on the Schwartz study to the NMMAPS study to reflect the effect of a distributed lag model.

The distributed lag adjustment factor is constructed as the ratio of the estimated coefficient from the unconstrained distributed lag model to the estimated coefficient from the single-lag model reported in Schwartz (2000)[20]. The unconstrained distributed lag model coefficient estimate is 0.0012818 and the single-lag model coefficient estimate is 0.0006479. The ratio of these estimates is 1.9784. This adjustment factor is then multiplied by the revised estimated coefficients from the NMMAPS study. The NMMAPS coefficient corresponding to the 0.224 percent increase in mortality risk is 0.000224. The adjusted NMMAPS coefficent is then 0.000224*1.9784 = 0.000444.

10.4.2 *Valuing Individual Health Effect Endpoints*

The appropriate economic value of a change in a health effect depends on whether the health effect is viewed ex ante (before the effect has occurred) or ex post (after the effect has occurred). Reductions in ambient concentrations of air pollution generally lower the risk of future adverse health affects by a fairly small amount for a large population. The appropriate economic measure is therefore ex ante WTP for changes in risk. However, epidemiological studies generally provide

[19]http://www.biostat.jhsph.edu/biostat/research/update.main.htm

[20]Both the single day and distributed lag models are likely to be affected to the same degree by the S-Plus convergence issue. As such, the ratio of the coefficients from the models should not be affected as much by any changes in the coefficient

estimates of the relative risks of a particular health effect avoided due to a reduction in air pollution. A convenient way to use this data in a consistent framework is to convert probabilities to units of avoided statistical incidences. This measure is calculated by dividing individual WTP for a risk reduction by the related observed change in risk. For example, suppose a measure is able to reduce the risk of premature mortality from 2 in 10,000 to 1 in 10,000 (a reduction of 1 in 10,000). If individual WTP for this risk reduction is $100, then the WTP for an avoided statistical premature mortality amounts to $1 million ($100/0.0001 change in risk). Using this approach, the size of the affected population is automatically taken into account by the number of incidences predicted by epidemiological studies applied to the relevant population. The same type of calculation can produce values for statistical incidences of other health endpoints.

For some health effects, such as hospital admissions, WTP estimates are generally not available. In these cases, we use the cost of treating or mitigating the effect as a primary estimate. For example, for the valuation of hospital admissions we use the avoided medical costs as an estimate of the value of avoiding the health effects causing the admission. These costs of illness (COI) estimates generally understate the true value of reductions in risk of a health effect. They tend to reflect the direct expenditures related to treatment but not the value of avoided pain and suffering from the health effect. In the NRD rule RIA and TSD, and the IAQR, we describe how the changes in health effects should be valued and indicate the value functions selected to provide monetized estimates of the value of changes in health effects. Table 10-5 below summarizes the value estimates per health effect that we used in this analysis. Note that the unit values for hospital admissions are the weighted averages of the ICD-9 code-specific values for the group of ICD-9 codes included in the hospital admission categories.

Table 10-5. Unit Values Used for Economic Valuation of Health Endpoints

Health or Welfare Endpoint	Estimated Value Per Incidence (1999$) Central Estimate	Derivation of Estimates
Premature Mortality (long-term exposure))	$6 million per statistical life	Value is the mean of value-of-statistical-life estimates from 26 studies (5 contingent valuation and 21 labor market studies) reviewed for the Section 812 Costs and Benefits of the Clean Air Act, 1990-2010 (US EPA, 1999).
Chronic Bronchitis	$331,000	Value is the mean of a generated distribution of WTP to avoid a case of pollution-related CB. WTP to avoid a case of pollution-related CB is derived by adjusting WTP (as described in Viscusi et al., 1991) to avoid a severe case of CB for the difference in severity and taking into account the elasticity of WTP with respect to severity of CB.
Hospital Admissions		
Chronic Obstructive Pulmonary Disease (COPD) (ICD codes 490-492, 494-496)	$12,378	The COI estimates are based on ICD-9 code level information (e.g., average hospital care costs, average length of hospital stay, and weighted share of total COPD category illnesses) reported in Elixhauser (1993).

Table 10-5. Unit Values Used for Economic Valuation of Health Endpoints

Health or Welfare Endpoint	Estimated Value Per Incidence (1999$) Central Estimate	Derivation of Estimates
Pneumonia (ICD codes 480-487)	$14,693	The COI estimates are based on ICD-9 code level information (e.g., average hospital care costs, average length of hospital stay, and weighted share of total pneumonia category illnesses) reported in Elixhauser (1993).
Asthma admissions	$6,634	The COI estimates are based on ICD-9 code level information (e.g., average hospital care costs, average length of hospital stay, and weighted share of total asthma category illnesses) reported in Elixhauser (1993).
All Cardiovascular (ICD codes 390-429)	$18,387	The COI estimates are based on ICD-9 code level information (e.g., average hospital care costs, average length of hospital stay, and weighted share of total cardiovascular illnesses) reported in Elixhauser (1993).
Emergency room visits for asthma	$299	COI estimate based on data reported by Smith, et al. (1997).

Table 10-5. Unit Values Used for Economic Valuation of Health Endpoints

Health or Welfare Endpoint	Estimated Value Per Incidence (1999$) Central Estimate	Derivation of Estimates
Respiratory Ailments Not Requiring Hospitalization		
Upper Respiratory Symptoms (URS)	$24	Combinations of the 3 symptoms for which WTP estimates are available that closely match those listed by Pope, et al. result in 7 different "symptom clusters," each describing a "type" of URS. A dollar value was derived for each type of URS, using mid-range estimates of WTP (IEc, 1994) to avoid each symptom in the cluster and assuming additivity of WTPs. The dollar value for URS is the average of the dollar values for the 7 different types of URS.
Lower Respiratory Symptoms (LRS)	$15	Combinations of the 4 symptoms for which WTP estimates are available that closely match those listed by Schwartz, et al. result in 11 different "symptom clusters," each describing a "type" of LRS. A dollar value was derived for each type of LRS, using mid-range estimates of WTP (IEc, 1994) to avoid each symptom in the cluster and assuming additivity of WTPs. The dollar value for LRS is the average of the dollar values for the 11 different types of LRS.
Acute Bronchitis	$57	Average of low and high values recommended for use in Section 812 analysis (Neumann, et al. 1994)
Restricted Activity and Work Loss Days		
Work Loss Days (WLDs)	Variable	Regionally adjusted median weekly wage for 1990 divided by 5 (adjusted to 1999$) (US Bureau of the Census, 1992).
Minor Restricted Activity Days (MRADs)	$48	Median WTP estimate to avoid one MRAD from Tolley, et al. (1986) .

Adjustments for Growth in Real Income

Our analysis also accounts for expected growth in real income over time. Economic theory argues that WTP for most goods (such as environmental protection) will increase if real incomes increase. The economics literature suggests that the severity of a health effect is a primary determinant of the strength of the relationship between changes in real income and WTP (Alberini, 1997; Miller, 2000; Viscusi, 1993). As such, we use different factors to adjust the WTP for minor health effects, severe and chronic health effects, and premature mortality. Adjustment factors used to account for projected growth in real income from 1990 to 2005 are 1.03 for minor health effects, 1.09 for severe and chronic health effects, and 1.08 for premature mortality.

10.4.2.1 Valuation of Reductions in Premature Mortality Risk

We estimate the monetary benefit of reducing premature mortality risk using the "value of statistical lives saved" (VSL) approach, which is a summary measure for the value of small changes in mortality risk experienced by a large number of people. The VSL approach applies information from several published value-of-life studies to determine a reasonable benefit of preventing premature mortality. The mean value of avoiding one statistical death is estimated to be $6 million in 1999 dollars. This represents an intermediate value from a range of estimates that appear in the economics literature, and it is a value the EPA has used in rulemaking support analyses and in the Section 812 Reports to Congress. This estimate is the mean of a distribution fitted to the estimates from 26 value-of-life studies identified in the Section 812 reports as "applicable to policy analysis." The approach and set of selected studies mirrors that of Viscusi (1992) (with the addition of two studies), and uses the same criteria as Viscusi in his review of value-of-life studies. The $6 million estimate is consistent with Viscusi's conclusion (updated to 1999$) that "most of the reasonable estimates of the value of life are clustered in the $3.7 to $8.6 million range." Five of the 26 studies are contingent valuation (CV) studies, which directly solicit WTP information from subjects; the rest are wage-risk studies, which base WTP estimates on estimates of the additional compensation demanded in the labor market for riskier jobs, controlling for other job and employee characteristics such as education and experience.

As indicated in the previous section on quantification of premature mortality benefits, we assume for this analysis that some of the incidences of premature mortality related to PM exposures occur in a distributed fashion over the five years following exposure. To take this into account in the valuation of reductions in premature mortality, we apply an annual three percent discount rate to the value of premature mortality occurring in future years[21].

The economics literature concerning the appropriate method for valuing reductions in premature mortality risk is still developing. The adoption of a value for the projected reduction in the risk of premature mortality is the subject of continuing discussion within the economic and public policy analysis community. Regardless of the theoretical economic considerations, the EPA prefers not to draw distinctions in the monetary value assigned to the lives saved even if they differ in age, health status, socioeconomic status, gender, or other characteristic of the adult population.

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[21]The choice of a discount rate, and its associated conceptual basis, is a topic of ongoing discussion within the federal government. The EPA adopted a 3 percent discount rate for its primary estimate in this case to reflect reliance on a "social rate of time preference" discounting concept. We have also calculated benefits and costs using a 7 percent rate consistent with an "opportunity cost of capital" concept to reflect the time value of resources directed to meet regulatory requirements. In this case, the benefit and cost estimates were not significantly affected by the choice of discount rate. Further discussion of this topic appears in the EPA's *Guidelines for Preparing Economic Analyses* (in press).

Following the advice of the EEAC of the SAB, the EPA currently uses the VSL approach in calculating the primary estimate of mortality benefits, because we believe this calculation provides the most reasonable single estimate of an individual's willingness to trade off money for reductions in mortality risk (EPA-SAB-EEAC-00-013). Although there are several differences between the labor market studies we use to derive a VSL estimate and the particulate matter air pollution context addressed here, those differences in the affected populations and the nature of the risks imply both upward and downward adjustments. In the absence of a comprehensive and balanced set of adjustment factors, the EPA believes it is reasonable to continue to use the $6 million value while acknowledging the significant limitations and uncertainties in the available literature.

Some economists emphasize that the value of a statistical life is not a single number relevant for all situations. Indeed, the VSL estimate of $6 million (1999 dollars) is itself the central tendency of a number of estimates of the VSL for some rather narrowly defined populations. When there are significant differences between the population affected by a particular health risk and the populations used in the labor market studies, as is the case here, some economists prefer to adjust the VSL estimate to reflect those differences.

There is general agreement that the value to an individual of a reduction in mortality risk can vary based on several factors, including the age of the individual, the type of risk, the level of control the individual has over the risk, the individual's attitudes towards risk, and the health status of the individual. While the empirical basis for adjusting the $6 million VSL for many of these factors does not yet exist, a thorough discussion of these factors is contained in the benefits TSD for the nonroad diesel rulemaking (Abt Associates, 2003). The EPA recognizes the need for investigation by the scientific community to develop additional empirical support for adjustments to VSL for the factors mentioned above.

The SAB-EEAC advised in their recent report that the EPA "continue to use a wage-risk-based VSL as its primary estimate, including appropriate sensitivity analyses to reflect the uncertainty of these estimates," and that "the only risk characteristic for which adjustments to the VSL can be made is the timing of the risk"(EPA-SAB-EEAC-00-013). In developing our primary estimate of the benefits of premature mortality reductions, we have followed this advice and discounted over the lag period between exposure and premature mortality.

<u>Uncertainties Specific to Premature Mortality Valuation</u>. The economic benefits associated with premature mortality are the largest category of monetized benefits of the NESHAP. In addition, in prior analyses, the EPA has identified valuation of mortality benefits as the largest contributor to the range of uncertainty in monetized benefits (see EPA [1999]). Because of the uncertainty in estimates of the value of premature mortality avoidance, it is important to adequately characterize and understand the various types of economic approaches available for mortality valuation. Such an assessment also requires an understanding of how alternative valuation approaches reflect that some individuals may be more susceptible to air pollution-induced mortality or reflect differences in the nature of the risk presented by air pollution relative to the risks studied in the relevant economics literature.

The health science literature on air pollution indicates that several human characteristics affect the degree to which mortality risk affects an individual. For example, some age groups appear to be more susceptible to air pollution than others (e.g., the elderly and children). Health status prior to exposure also affects susceptibility. An ideal benefits estimate of mortality risk reduction would reflect these human characteristics, in addition to an individual's WTP to improve one's own chances of survival plus WTP to improve other individuals' survival rates. The ideal measure would also take into account the specific nature of the risk reduction commodity that is provided to individuals, as well as the context in which risk is reduced. To measure this value, it is important to assess how reductions in air pollution reduce the risk of dying from the time that reductions take effect onward, and how individuals value these changes. Each individual's survival curve, or the probability of surviving beyond a given age, should shift as a result of an environmental quality improvement. For example, changing the current probability of survival for an individual also shifts future probabilities of that individual's survival. This probability shift will differ across individuals because survival curves depend on such characteristics as age, health state, and the current age to which the individual is likely to survive.

Although a survival curve approach provides a theoretically preferred method for valuing the benefits of reduced risk of premature mortality associated with reducing air pollution, the approach requires a great deal of data to implement. The economic valuation literature does not yet include good estimates of the value of this risk reduction commodity. As a result, in this study we value avoided premature mortality risk using the VSL approach.

Other uncertainties specific to premature mortality valuation include the following:

- Across-study variation: There is considerable uncertainty as to whether the available literature on VSL provides adequate estimates of the VSL saved by air pollution reduction. Although there is considerable variation in the analytical designs and data used in the existing literature, the majority of the studies involve the value of risks to a middle-aged working population. Most of the studies examine differences in wages of risky occupations, using a wage-hedonic approach. Certain characteristics of both the population affected and the mortality risk facing that population are believed to affect the average WTP to reduce the risk. The appropriateness of a distribution of WTP based on the current VSL literature for valuing the mortality-related benefits of reductions in air pollution concentrations therefore depends not only on the quality of the studies (i.e., how well they measure what they are trying to measure), but also on the extent to which the risks being valued are similar and the extent to which the subjects in the studies are similar to the population affected by changes in pollution concentrations.

- Level of risk reduction: The transferability of estimates of the VSL from the wage-risk studies to the context of the Interstate Air Quality Rulemaking analysis rests on the assumption that, within a reasonable range, WTP for reductions in mortality risk is linear in risk reduction. For example, suppose a study estimates that the average WTP for a reduction in mortality risk of 1/100,000 is $50, but that the actual mortality risk reduction resulting from a given pollutant reduction is 1/10,000. If WTP for reductions in mortality risk is linear in risk reduction, then a WTP of $50 for a reduction of 1/100,000 implies a WTP of $500 for a risk reduction of 1/10,000 (which is 10 times the risk reduction valued in the study). Under the assumption of linearity, the estimate of the VSL does not depend on the particular amount of risk reduction being valued. This assumption has been shown to be reasonable provided the change in the risk being valued is within the range of risks evaluated in the underlying studies (Rowlatt et al., 1998).

- Voluntariness of risks evaluated: Although job-related mortality risks may differ in several ways from air pollution-related mortality risks, the most important difference may be that job-related risks are incurred voluntarily, or generally assumed to be, whereas air pollution-related risks are incurred involuntarily. Some evidence suggests that people will pay more to reduce involuntarily incurred risks than risks incurred voluntarily. If this is the case, WTP estimates based on wage-risk studies may understate WTP to reduce involuntarily incurred air pollution-related mortality risks.

- Sudden versus protracted death: A final important difference related to the nature of the risk may be that some workplace mortality risks tend to involve sudden, catastrophic events, whereas air pollution-related risks tend to involve longer periods of disease and suffering prior to death. Some evidence suggests that WTP to avoid a risk of a protracted death involving prolonged suffering and loss of dignity and personal control is greater than the WTP to avoid a risk (of identical magnitude) of sudden death. To the extent that the mortality risks addressed in this assessment are associated with longer periods of illness or greater pain and suffering than are the risks addressed in the valuation literature, the WTP measurements employed in the present analysis would reflect a downward bias.

- Self-selection and skill in avoiding risk. Recent research (Shogren et al., 2002) suggests that VSL estimates based on hedonic wage studies may overstate the average value of a risk reduction. This is based on the fact that the risk-wage tradeoff revealed in hedonic studies reflects the preferences of the marginal worker (i.e., that worker who demands the highest compensation for his risk reduction). This worker must have either higher risk, lower risk tolerance, or both. However, the risk estimate used in hedonic studies is generally based on average risk, so the VSL may be upwardly biased because the wage differential and risk measures do not match.

10.4.2.2 Valuation of Reductions in Chronic Bronchitis

The best available estimate of WTP to avoid a case of chronic bronchitis (CB) comes from Viscusi, et al. (1991). The Viscusi, et al. study, however, describes a severe case of CB to the survey respondents. We therefore employ an estimate of WTP to avoid a pollution-related case of CB, based on adjusting the Viscusi, et al. (1991) estimate of the WTP to avoid a severe case. This is done to account for the likelihood that an average case of pollution-related CB is not as severe. The adjustment is made by applying the elasticity of WTP with respect to severity reported in the Krupnick and Cropper (1992) study. Details of this adjustment procedure can be found in the IAQR and its supporting documentation, and in the most recent Section 812 study (EPA 1999).

We use the mean of a distribution of WTP estimates as the central tendency estimate of WTP to avoid a pollution-related case of CB in this analysis. The distribution incorporates uncertainty from three sources: (1) the WTP to avoid a case of severe CB, as described by Viscusi, et al.; (2) the severity level of an average pollution-related case of CB (relative to that of the case described by Viscusi, et al.); and (3) the elasticity of WTP with respect to severity of the illness. Based on assumptions about the distributions of each of these three uncertain components, we derive a distribution of WTP to avoid a pollution-related case of CB by statistical uncertainty analysis techniques. The expected value (i.e., mean) of this distribution, which is about $331,000 (1999$), is taken as the central tendency estimate of WTP to avoid a PM-related case of CB.

10.4.3 *Results of Phase One Analysis: Benefits Resulting from a Portion of Emission Reductions at a Subset of Boiler and Process Heater Sources*

Applying the C-R and valuation functions described above to the estimated changes in PM from phase one of our analysis yields estimates of the number of avoided incidences (i.e. premature mortalities, cases, admissions, etc.) and the associated monetary values for those avoided incidences. In Table 10-6, we provide the results for the MACT floor option resulting from the phase one analysis. Tables 10-7 present the results for the above the MACT floor option resulting from the phase one analysis. To obtain a total benefit estimate, we aggregate dollar benefits associated with each of the health effects examined, such as hospital admissions, assuming that none of the included health and welfare effects overlap. All of the monetary benefits are in constant 1999 dollars.

As we have discussed, not all known PM-related health and welfare effects could be quantified or monetized. These unmonetized benefits are indicated in Tables 10-6 and 10-7 by place holders, labeled B_1 and B_2. In addition, unmonetized benefits associated with HAP reductions are indicated by the placeholder B_3. Unquantified reduce incidences of physical effects are indicated by U_1 and U_2. The estimate of total monetized health benefits is thus equal to the subset of monetized PM-related health benefits plus B_H, the sum of the unmonetized health benefits.

Table 10-6. Phase One Analysis: Estimate of Annual Benefits Associated with Approximately 50% of the Emission Reductions from the Industrial Boilers/Process Heaters NESHAP (MACT Floor Regulatory Option in 2005) Using Air Quality Modeling & the CAPMS Benefit Model[A, B]

Endpoint	Avoided Incidence[C] (cases/year)	Monetary Benefits[D] (millions 1999$, adjusted for growth in real income)
Premature mortality[E,F] (long-term exposure, adults 30 and over)		
-Using a 3% discount rate	1,170	$7,325
-Using a 7% discount rate	1,170	$6,880
Chronic bronchitis (adults, 26 and over, WTP valuation)	2,340	$845
Hospital Admissions – Pneumonia (adults, over 64)	500	$5
Hospital Admissions – COPD (adults, 64 and over)	420	$5
Hospital Admissions – Asthma (65 and younger)	120	$1
Hospital Admissions – Cardiovascular (adults, over 64)	1,230	$25
Emergency Room Visits for Asthma (65 and younger)	930	<$1
Asthma Attacks (asthmatics, all ages)	79,020	B_1
Acute bronchitis (children, 8-12)	2,430	<$1
Lower respiratory symptoms (children, 7-14)	26,470	<$1
Upper respiratory symptoms (asthmatic children, 9-11)	89,480	$5
Work loss days (adults, 18-65)	205,400	$20
Minor restricted activity days (adults, age 18-65)	1,011,200	$50
Other PM-related health effects[G]	U_1	B_2
HAP health effects[G]	U_2	B_3
Total Monetized Health-Related Benefits[F]		
-Using a 3% discount rate	—	$8,280+$\mathbf{B_H}$
-Using a 7% discount rate	—	$7,835+$\mathbf{B_H}$

[A] The results presented in this table are based on those SO_2 and PM emission reductions identified for specific sources included in the Inventory Database. This includes approximately 50% of all emission reductions estimated by the rule. The location of all other emission reductions (i.e. non-inventory reductions) cannot be determined specifically and hence cannot be modeled in an air quality model. See Section 10.5 and Appendix D for benefit estimation of non-inventory emission reductions.
[B] The results presented in this table reflect the outcome of the combination of PM and SO_2 model runs. See Appendix D for a presentation of results for each pollutant independently.
[C] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.
[D] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.
[E] Note that the estimated value for PM-related premature mortality assumes the 5 year distributed lag structure described in detail in the Regulatory Impact Analysis of Heavy Duty Engine/Diesel Fuel rule.
[F] Monetized benefits are presented using two different discount rates. Results calculated using 3 percent discount rate are recommended by EPA's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a). Results calculated using 7 percent discount rate are recommended by OMB Circular A-94 (OMB, 1992).
[G] A detailed listing of unquantified PM and HAP related health effects is provided in Table 10-17.

Thus, the estimate of total monetized benefits for phase one of the Industrial Boilers/Process Heaters NESHAP benefit analysis associated with the MACT floor is approximately \$8 billion + B_H (using either a 3% or 7% discount rate). The benefits of phase one in combination with the phase two estimate of benefits will serve as the basis for our estimate of the total benefits of the regulation.

For the Above the MACT floor option of this NESHAP, Table 10-7 indicates that the estimate of total monetized benefits for phase one of the analysis is approximately \$10 billion + B_H using a 3% discount rate (or approximately \$9.5 billion using a 7% discount rate).

Table 10-7. Phase One Analysis: Estimate of Annual Benefits Associated with Approximately 50% of the Emission Reductions from the Industrial Boilers/Process Heaters NESHAP (Above the MACT Floor Regulatory Option in 2005) Using Air Quality Modeling & the CAPMS Benefit Model[A, B]

Endpoint	Avoided Incidence[C] (cases/year)	Monetary Benefits[D] (millions 1999$, adjusted for growth in real income)
Premature mortality[E,F] (long-term exposure, adults, 30 and over)		
-Using a 3% discount rate	1,390	$8,740
-Using a 7% discount rate	1,390	$8,210
Chronic bronchitis (adults, 26 and over, WTP valuation)	2,860	$1,030
Hospital Admissions – Pneumonia (adults, over 64)	610	$10
Hospital Admissions – COPD (adults, 64 and over)	500	$5
Hospital Admissions – Asthma (65 and younger)	140	$1
Hospital Admissions – Cardiovascular (adults, over 64)	1,480	$25
Emergency Room Visits for Asthma (65 and younger)	1,140	<$1
Asthma Attacks (asthmatics, all ages)	97,060	B_1
Acute bronchitis (children, 8-12)	2,870	<$1
Lower respiratory symptoms (children, 7-14)	31,290	<$1
Upper respiratory symptoms (asthmatic children, 9-11)	110,370	$5
Work loss days (adults, 18-65)	243,870	$25
Minor restricted activity days (adults, age 18-65)	1,196,500	$60
Other PM-related health effects[F]	U_1	B_2
HAP health effects[G]	U_2	B_3
Total Monetized Health-Related Benefits[F]		
-Using a 3% discount rate	—	$9,905+$\mathbf{B_H}$
-Using a 7% discount rate	—	$9,375+$\mathbf{B_H}$

[A] The results presented in this table are based on those SO_2 and PM emission reductions identified for specific sources included in the Inventory Database. This includes approximately 50% of all emission reductions estimated by the rule. The location of all other emission reductions (i.e. non-inventory reductions) cannot be determined specifically and hence cannot be modeled in an air quality model. See Section 10.5 and Appendix D for benefit estimation of non-inventory emission reductions.
[B] The results presented in this table reflect the outcome of the combination of PM and SO_2 model runs. See Appendix D for a presentation of results for each pollutant independently.
[C] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.
[D] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.
[E] Note that the estimated value for PM-related premature mortality assumes the 5 year distributed lag structure described in detail in the Regulatory Impact Analysis of Heavy Duty Engine/Diesel Fuel rule.
[E] Monetized benefits are presented using two different discount rates. Results calculated using 3 percent discount rate are recommended by EPA's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a). Results calculated using 7 percent discount rate are recommended by OMB Circular A-94 (OMB, 1992).
[F] A detailed listing of unquantified PM and HAP related health effects is provided in Table 10-17.

10.5 Phase Two Analysis: Benefit Transfer Valuation of Remaining Emission Reductions

As is mentioned previously, only a portion of the expected emission reductions of the rule can be mapped to specific locations and hence modeled to determine the change in air quality (e.g., change in ambient PM concentrations). For approximately 50% of the PM reductions and approximately 30% of the SO_2 reductions, the lack of location-specific data prevents us from utilizing the S-R Matrix to determine air quality changes and the CAPMS model to estimate total benefits. We can assume, however, that these reductions are achieved uniformly throughout the country because the location of boilers/process heaters in the U.S. is spread fairly evenly across all states. To estimate benefits for these reductions, we use the results of the air quality and benefit analysis provided in phase one to infer the average benefit value per ton of emission reduction for each pollutant - PM and SO_2. The benefit transfer values for PM and SO_2 are then applied to all remaining emission reductions to approximate total benefits of phase two of this analysis.

Before determining the benefit value to transfer to these reductions, one consideration must first be made. The total benefits that result from the air quality analysis of phase one is due to the combination of both direct PM reductions and SO_2 reductions that transform into secondary PM. Without knowledge of the percent of the total benefits in phase one that can be attributed to direct PM versus the percent of phase one benefits attributed to SO_2, we cannot accurately assign the monetized benefits to the tons reduced of each pollutant. To correctly apportion the total benefit value from phase one to the respective PM and SO_2 reductions, we performed two additional S-R Matrix model runs of the reductions valued in phase one; one evaluation of the benefits of the PM reductions alone (holding SO_2 unchanged), and one run of the benefits of the SO_2 reductions alone (holding PM reductions unchanged). This allows us to determine the appropriate benefit transfer value for each individual pollutant. Because the combined effect of reducing both PM and SO_2 simultaneously at one location would result in a larger change in the concentration of PM, it can be expected that the air quality analyses of each pollutant alone will result in lower changes in concentrations and hence lower calculated benefits. The air quality and benefit assessment of the individual pollutants are again performed for each regulatory option: the MACT floor, and the above the MACT floor option. The detailed results of the additional air quality and benefit model runs are reported in Appendix D.

These data, along with the set of C-R and valuation functions contained in CAPMS, constitute the input set for the benefits transfer value function. The benefits transfer function for each pollutant is specified as:

$$\mathit{Transfer\ \ Value} = \frac{\mathit{Benefits}}{\mathit{Emission\ \ Reductions}}$$

The numerator in the transfer value formula is total monetary benefits, which is determined by applying the same economic valuation functions specified in Table 10-5 to changes in incidences of human health endpoints resulting from the air quality modeling of each pollutant separately. In Appendix D, we show the calculated benefit transfer value of the total monetized benefits of PM alone and SO_2 alone and also for each individual endpoint included in this analysis.

A similar calculation is also done for the number of incidences associated with each endpoint. From the air quality assessments of PM and SO_2 alone, we divide total incidences of an endpoint by the total emission reductions included in the air quality scenario. Therefore, we determine a measure of the number of incidences of each health effect that can result from a ton of pollutant reductions (for example, 0.10 fewer asthma cases per ton reduced). This allows us to transfer the incidence per ton reduced to the remaining set of emission reductions of the phase two analysis.

Note that for both dollar and incidence per ton estimates, we assume that each ton of pollutant has the same impact, so that subnational applications are inappropriate as the national application requires assuming populations are uniformly distributed throughout the U.S.

Once all transfer values are determined for each endpoint and total benefits, we apply them to the set of phase two emission reductions. Finally, we combine our phase two estimates of benefits with the phase one calculated benefits to provide an estimate of total benefits for each endpoint and determine the total monetized benefits associated with the rule.

Sections 10.5.1 and 10.5.2 provide further detail on the transfer values obtained for SO_2 and PM in this analysis.

10.5.1 SO_2 *Benefits Transfer Values*

Using the results of the air quality analysis of SO_2 reductions alone (holding PM unchanged) from phase one, we can extract information on the total number of incidences and total benefit value of each endpoint to estimate the SO_2 benefit transfer values. As an example of the calculation consider the following: the total SO_2 emission reductions applied in the S-R matrix analysis for phase one of this analysis are 82,542 tons. Under the MACT floor, the analysis yields approximately 240 fewer premature deaths at a total value of $1.5 billion (see Appendix D for details)**.** Therefore, the benefit transfer value to apply to SO_2 emission reductions in the phase two analysis associated with the mortality endpoint would on average be $18,385 per ton reduced. This procedure is repeated for each endpoint and for the total benefits estimate associated with SO_2 reductions alone. Further, based on these results it can be estimated that SO_2 reductions from the MACT floor on average result in 0.003 fewer incidences of mortality per ton reduced (240 incidences/82,542 tons).

The following tables present the incidence and benefits data necessary to calculate the benefits transfer values for SO_2. Table 10-8 present the benefit transfer values for the MACT floor option, while Table 10-9 presents benefit transfer values associated with the Above the MACT floor option. The benefits transfer values for SO_2 emission reductions are reported in 1999 dollars. Differences in benefit/ton estimates between the MACT floor option and the above the floor option may be due to differences in the location of emission reductions and other factors. In particular, while PM reductions from process heaters are not expected to accrue at the MACT floor level of control, approximately 18,300 tons are estimate for the above the floor option. The Inventory Database provides information on the location of the majority of process heaters and thus we can apply a large percentage of these reductions directly into the air quality and benefit analysis. In addition, the process heaters affected by this proposal are largely found at large facilities located near large cities, thus the changes in air quality are applied to the populated areas around the cities.

Table 10-8. SO_2 Benefit Transfer Values Based on Data From Phase One Analysis
MACT Floor Regulatory Option[A]

Endpoint	Avoided Incidence[B] (cases/year)	Incidence Per Ton Reduced[C]	Monetary Benefits[D] (millions 1999$, adjusted for growth in real income)	Total Benefit Per Ton Reduced[C] ($/ton)
Premature mortality[E] (long-term exposure, adults 30 and over)				
-Using a 3% discount rate	240	0.0029	$1,520	$18,385
-Using a 7% discount rate	240	0.0029	$1,425	$17,270
Chronic bronchitis (adults, 26 and over, WTP valuation)	320	0.0039	$115	$1,400
Hospital Admissions – Pneumonia (adults, over 64)	60	0.0008	$1	$10
Hospital Admissions – COPD (adults, 64 and over)	50	0.0006	$1	$5
Hospital Admissions – Asthma (65 and younger)	20	0.0003	<$1	<$5
Hospital Admissions – Cardiovascular (adults, over 64)	150	0.0018	$5	$30
Emergency Room Visits for Asthma (65 and younger)	130	0.0016	<$1	<$1
Asthma Attacks (asthmatics, all ages)	11,120	0.1347	B_1	B_1
Acute bronchitis (children, 8-12)	490	0.0059	<$1	<$1
Lower respiratory symptoms (children, 7-14)	5,330	0.0645	<$1	$1
Upper respiratory symptoms (asthmatic children, 9-11)	12,980	0.1572	<$1	$5
Work loss days (adults, 18-65)	42,611	0.5162	$5	$55
Minor restricted activity days (adults, age 18-65)	214,592	2.5998	$10	$130
Other PM-related health effects[F]	U_1	-----	B_2	B_2
HAP-related health effects[F]	U_2	-----	B_3	B_3
Total Benefits of SO_2-Related Reductions[E]				
-Using a 3% discount rate	—	-----	$1,650	$20,030+$\mathbf{B_H}$
-Using a 7% discount rate	—	-----	$1,560	$18,910+$\mathbf{B_H}$

[A] Results of the phase one benefit analysis of SO_2 emission reductions are presented in Appendix D, and replicated in columns 2 and 4 of this table.
[B] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.
[C] Total SO_2 emission reductions included in the phase one analysis and applied to derive the benefit transfer values of this table are 82,542 tons.
[D] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.
[E] Monetized benefits are presented using two different discount rates. Results calculated using 3 percent discount rate are recommended by EPA's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a). Results calculated using 7 percent discount rate are recommended by OMB Circular A-94 (OMB, 1992).

Table 10-9. SO_2 Benefit Transfer Values Based on Data From Phase One Analysis
Above the MACT Floor Regulatory Option[A]

Endpoint	Avoided Incidence[B] (cases/year)	Incidence Per Ton Reduced[C]	Monetary Benefits[D] (millions 1999$, adjusted for growth in real income)	Total Benefit Per Ton Reduced[C] ($/ton)
Premature mortality (long-term exposure, adults, 30 and over)				
-Using a 3% discount rate	310	0.0032	$1,935	$20,305
-Using a 7% discount rate	310	0.0032	$1,820	$19,070
Chronic bronchitis (adults, 26 and over, WTP valuation)	400	0.0042	$145	$1,500
Hospital Admissions – Pneumonia (adults, over 64)	70	0.0007	$1	$10
Hospital Admissions – COPD (adults, 64 and over)	60	0.0006	$1	$10
Hospital Admissions – Asthma (65 and younger)	30	0.0003	<$1	<$5
Hospital Admissions – Cardiovascular (adults, over 64)	170	0.0018	$5	$35
Emergency Room Visits for Asthma (65 and younger)	150	0.0015	<$1	<$1
Asthma Attacks (asthmatics, all ages)	12,250	0.1284	B_1	B_1
Acute bronchitis (children, 8-12)	660	0.0069	<$1	<$1
Lower respiratory symptoms (children, 7-14)	7,170	0.0752	<$1	$1
Upper respiratory symptoms (asthmatic children, 9-11)	14,160	0.1485	<$1	$5
Work loss days (adults, 18-65)	54,980	0.5765	$5	$60
Minor restricted activity days (adults, age 18-65)	279,760	2.9337	$15	$145
Other PM-related health effects	U_1	-----	B_2	B_2
HAP-related health effects	U_2	-----	B_3	B_3
Total Benefits of SO_2-Related Reductions				
-Using a 3% discount rate	—	-----	$2,105	$22,070+**$B_H$**
-Using a 7% discount rate	—	-----	$1,990	$20,840+**$B_H$**

[A] Results of the phase one benefit analysis of SO_2 emission reductions are presented in Appendix D, and replicated in columns 2 and 4 of this table.
[B] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.
[C] Total SO_2 emission reductions included in the phase one analysis and applied to derive the benefit transfer values of this table are 95,361 tons.
[D] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.

10.5.2 *PM Benefits Transfer Values*

The transfer values for PM are developed using the same basic approach as for the SO_2 reductions. However, the PM benefits analysis conducted for this RIA includes health benefits associated with reductions in both $PM_{2.5}$ and PM_{10}. Therefore, the benefit transfer values for endpoints associated with $PM_{2.5}$ alone will be established using an estimate of the portion of total PM reductions that are likely to be $PM_{2.5}$. Likewise the benefit endpoints associated with PM_{10} alone require an estimate of PM_{10} emission reductions to derive the benefit transfer value for such endpoints. Fortunately, the S-R Matrix model has a component that can approximate $PM_{2.5}$ emissions from a total change in PM. Based on this approximation, of the 265,155 tons of PM_{10} emission reductions included in the air quality analysis of the MACT floor from phase one, approximately 75,095 tons are $PM_{2.5}$.[22]

The endpoints associated with $PM_{2.5}$ are long-term mortality, minor restricted activity days (MRAD), and acute respiratory symptoms. All other endpoints are associated with PM_{10} reductions. For the MACT floor option, Tables 10-9 present the total incidence and benefits data for each endpoint from the phase one analysis , and the calculated the benefits transfer values for PM that are to be applied for the phase two analysis. Table 10-10 present similar data for the above the MACT floor regulatory option.

[22] Reductions in $PM_{2.5}$ are derived as a function of the estimated PM_{10} reductions. The S-R matrix model contains coefficients that relate reductions in both directly emitted PM_{10} and directly emitted $PM_{2.5}$. At the time the S-R matrix was being developed in the early 1990s, a nationwide inventory of directly emitted $PM_{2.5}$ emissions was not available, so the author developed a method for crudely estimating $PM_{2.5}$ emissions from PM_{10} emissions. The air quality changes predicted by the model for direct $PM_{2.5}$ were then developed from these crude emissions estimates. A full discussion of the derivation of $PM_{2.5}$ estimates is provided in E.H. Pechan (1994 and 1996), and Latimer and Associates(1996). The PM Calculator Tool can also be found on the Internet at www.epa.gov/chief/software/pmcalc/index.html.

Table 10-10. PM Benefit Transfer Values Based on Data From Phase One Analysis

MACT Floor Regulatory Option[A]

Endpoint	Avoided Incidence[B] (cases/year)	Incidence Per Ton Reduced[C]	Monetary Benefits[D] (millions 1999$, adjusted for growth in real income)	Total Benefit Per Ton Reduced[C] ($/ton)
Premature mortality (long-term, adults, 30 and over) -Using a 3% discount rate	900	0.01202	$5,675	$75,595
-Using a 7% discount rate	900	0.01202	$5,330	$71,005
Chronic bronchitis (adults, 26 and over, WTP valuation)	2,360	0.0089	$850	$3,195
Hospital Admissions – Pneumonia (adults, over 64)	510	0.0019	$10	$30
Hospital Admissions – COPD (adults, 64 and over)	420	0.0016	$5	$20
Hospital Admissions – Asthma (65 and younger)	90	0.0012	$1	$10
Hospital Admissions – Cardiovascular (adults, over 64)	1,230	0.0046	$25	$85
Emergency Room Visits for Asthma (65 and younger)	950	0.0036	<$1	$1
Asthma Attacks (asthmatics, all ages)	80,700	0.3043	B_1	B_1
Acute bronchitis (children, 8-12)	1,870	0.0248	<$1	$1
Lower respiratory symptoms (children, 7-14)	20,370	0.2712	<$1	$5
Upper respiratory symptoms (asthmatic children, 9-11)	91,620	0.3455	$5	$10
Work loss days (adults, 18-65)	158,560	2.1115	$20	$225
Minor restricted activity days (adults, age 18-65)	760,870	10.132	$40	$500
Other PM-related health effects	U_1	-----	B_2	B_2
HAP-related health effects	U_2	-----	B_3	B_3
Total Benefits of PM-Related Reductions -Using a 3% discount rate)	—	-----	$6,620	$88,120+$\mathbf{B_H}$
-Using a 7% discount rate	—	-----	$6,275	$83,530+$\mathbf{B_H}$

[A] Results of the phase one benefit analysis of PM emission reductions are presented in Appendix D, and replicated in columns 2 and 4 of this table.
[B] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.
[C] Total PM_{10} and $PM_{2.5}$ emission reductions included in the phase one analysis and applied to derive the benefit transfer values of this table are 265,155 tons and 75,095 tons, respectively.
[D] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.

Table 10-11. PM Benefit Transfer Values
Based on Data From Phase One Analysis
Above the MACT Floor Regulatory Option[A]

Endpoint	Avoided Incidence[B] (cases/year)	Incidence Per Ton Reduced[C]	Monetary Benefits[D] (millions 1999$, adjusted for growth in real income)	Total Benefit Per Ton Reduced[C]
Premature mortality (long-term exposure, adults, 30 and over)				
-Using a 3% discount rate	1,090	0.0115	$6,835	$72,290
-Using a 7% discount rate	1,090	0.0115	$6,420	$67,900
Chronic bronchitis (adults, 26 and over, WTP valuation)	2,680	0.0085	$965	$3,070
Hospital Admissions – Pneumonia (adults, over 64)	570	0.0018	$10	$30
Hospital Admissions – COPD (adults, 64 and over)	470	0.0015	$5	$20
Hospital Admissions – Asthma (65 and younger)	110	0.0012	$1	$10
Hospital Admissions – Cardiovascular (adults, over 64)	1,390	0.0044	$25	$80
Emergency Room Visits for Asthma (65 and younger)	1,070	0.0034	<$1	$1
Asthma Attacks (asthmatics, all ages)	90,940	0.2897	B_1	B_1
Acute bronchitis (children, 8-12)	2,230	0.0236	<$1	$1
Lower respiratory symptoms (children, 7-14)	24,330	0.2572	<$1	$5
Upper respiratory symptoms (asthmatic children, 9-11)	103,400	0.3294	$5	$10
Work loss days (adults, 18-65)	190,370	2.0131	$20	$215
Minor restricted activity days (adults, age 18-65)	918,650	9.7144	$45	$485
Other PM-related health effects	U_1	-----	B_2	B_2
HAP-related health effects	U_2	-----	B_3	B_3
Total Benefits of PM-Related Reductions				
-Using a 3% discount rate	—	-----	$7,910	$83,645+**$B_H$**
-Using a 7% discount rate	—	-----	$7,495	$79,255+**$B_H$**

[A] Results of the phase one benefit analysis of PM emission reductions are presented in Appendix D, and replicated in columns 2 and 4 of this table.
[B] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.
[C] Total PM_{10} and $PM_{2.5}$ emission reductions included in the phase one analysis and applied to derive the benefit transfer values of this table are 313,947 tons and 94,565 tons, respectively.
[D] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.

10.5.3 *Application of Benefits Transfer Values to Phase Two Emission Reductions*

Emission reductions included in phase two of our benefit analysis are summarized in Table 10-2. These reductions will be applied to the benefit transfer values developed in the previous section. These emission reductions are derived by simply subtracting the emission reductions including in the phase one analysis from the total emission reductions anticipated from this NESHAP.

Thus, in the final step of the phase two analysis, the transfer values calculated in section 10.5.3 are multiplied by the emission reductions associated with the phase two analysis. Appendix D provides tables showing the benefit estimation for each pollutant (PM and SO_2) separately. In the tables below, we combine the total SO_2 benefits of phase two with the total PM benefits of phase two from Appendix D to provide a summary of total benefits associated with phase two of this analysis for each regulatory option analyzed.

Table 10-12. Phase Two Analysis: Annual Health Benefits Associated with Non-Inventory Emission Reductions of the Industrial Boilers/Process Heaters NESHAP - MACT Floor Regulatory Option in 2005, Using Benefit Transfer Values[A]

Endpoint	Avoided Incidence[B] (cases/year)	Monetary Benefits[C] (millions 1999$, adjusted for growth in real income)
Premature mortality[D] (long-term exposure, adults, 30 and over)		
-Using a 3% discount rate	1,100	$6,920
-Using a 7% discount rate	1,110	$6,495
Chronic bronchitis (adults, 26 and over, WTP valuation)	2,760	$990
Hospital Admissions – Pneumonia (adults, over 64)	590	$10
Hospital Admissions – COPD (adults, 64 and over)	490	$5
Hospital Admissions – Asthma (65 and younger)	110	$1
Hospital Admissions – Cardiovascular (adults, over 64)	1,430	$25
Emergency Room Visits for Asthma (65 and younger)	1,110	<$1
Asthma Attacks (asthmatics, all ages)	94,470	B_1
Acute bronchitis (children, 8-12)	2,270	<$1
Lower respiratory symptoms (children, 7-14)	24,770	<$1
Upper respiratory symptoms (asthmatic children, 10-11)	107,380	<$5
Work loss days (adults, 18-65)	193,270	$20
Minor restricted activity days (adults, age 18-65)	931,140	$45
Other PM-related health effects[E]	U_1	B_2
HAP-related health effects[E]	U_2	B_3
Total Monetized Health-Related Benefits		
-Using a 3% discount rate	—	$8,020+$\mathbf{B_H}$
-Using a 7% discount rate	—	$7,600+$\mathbf{B_H}$

[A] The results presented in this table reflect the outcome of the combination of PM and SO_2 benefit estimates from the application of benefit transfer values applied in the phase two analysis. See Appendix D for a presentation of results for each pollutant independently.
[B] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.
[C] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.
[D] Note that the estimated value for PM-related premature mortality assumes the 5 year distributed lag structure described in detail in the Regulatory Impact Analysis of Heavy Duty Engine/Diesel Fuel rule.
[E] A detailed listing of unquantified PM and HAP related health effects is provided in Table 10-16.

Table 10-13. Phase Two Analysis: Annual Health Benefits Associated with Non-Inventory Emission Reductions of the Industrial Boilers/Process Heaters NESHAP - Above the MACT Floor Regulatory Option in 2005, Using Benefit Transfer Values[A]

Endpoint	Avoided Incidence[B] (cases/year)	Monetary Benefits[C] (millions 1999$, adjusted for growth in real income)
Premature mortality[D] (long-term exposure, adults, 30 and over)		
-Using a 3% discount rate	1,020	$6,400
-Using a 7% discount rate	1,020	$6,010
Chronic bronchitis (adults, 26 and over, WTP valuation)	2,350	$850
Hospital Admissions – Pneumonia (adults, over 64)	500	$10
Hospital Admissions – COPD (adults, 64 and over)	410	$5
Hospital Admissions – Asthma (65 and younger)	100	$1
Hospital Admissions – Cardiovascular (adults, over 64)	1,200	$20
Emergency Room Visits for Asthma (65 and younger)	930	<$1
Asthma Attacks (asthmatics, all ages)	79,260	B_1
Acute bronchitis (children, 8-12)	2,100	<$1
Lower respiratory symptoms (children, 7-14)	22,890	<$1
Upper respiratory symptoms (asthmatic children, 10-11)	90,220	<$5
Work loss days (adults, 18-65)	178,650	$20
Minor restricted activity days (adults, age 18-65)	868,360	$45
Other PM-related health effects[E]	U_1	B_2
HAP-related health effects[E]	U_2	B_3
Total Monetized Health-Related Benefits		
-Using a 3% discount rate	—	$7,350+$\mathbf{B_H}$
-Using a 7% discount rate	—	$6,960+$\mathbf{B_H}$

[A] The results presented in this table reflect the outcome of the combination of PM and SO_2 benefit estimates from the application of benefit transfer values applied in the phase two analysis. See Appendix D for a presentation of results for each pollutant independently.
[B] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.
[C] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.
[D] Note that the estimated value for PM-related premature mortality assumes the 5 year distributed lag structure described in detail in the Regulatory Impact Analysis of Heavy Duty Engine/Diesel Fuel rule.
[E] A detailed listing of unquantified PM and HAP related health effects is provided in Table 10-16.

10.6 Total Benefits of the Industrial Boilers/Process Heaters NESHAP

Given the estimates of benefits from phases one and two of this analysis, this section combines those results to present the estimate of total benefits of the NESHAP. To obtain this estimate, we aggregate dollar benefits associated with each of the effects examined, such as hospital admissions, into a total benefits estimate assuming that none of the included health and welfare effects overlap. The benefits associated with the health and welfare effects is the sum of the separate effects estimates. Total monetized benefits associated with the MACT floor regulatory option of the Industrial Boilers/Process Heaters NESHAP are listed in Table 10-14, along with a breakdown of benefits by endpoint. Table 10-15 provides total annual benefits of the above the MACT floor option.

Again, note that the value of endpoints known to be affected by PM that we are not able to monetize are assigned a placeholder value (e.g., B_1, B_2, etc.). Unquantified physical effects are indicated by a U. The estimate of total benefits is thus the sum of the monetized benefits and a constant, B, equal to the sum of the unmonetized benefits, B_1+B_2+...+B_n.

A comparison of the incidence column to the monetary benefits column reveals that there is not always a close correspondence between the number of incidences avoided for a given endpoint and the monetary value associated with that endpoint. For example, under the MACT floor option there are over 75 times more asthma attacks than premature mortalities, yet these asthma attacks account for only a very small fraction of total monetized benefits. This reflects the fact that many of the less severe health effects, while more common, are valued at a lower level than the more severe health effects. Also, some effects, such as asthma attacks, are valued using a proxy measure of WTP. As such the true value of these effects may be higher than that reported in Table 10-14 and Table 10-15.

The estimate of total monetized benefits for the MACT floor is $16.3 billion when using a 3 percent discount rate (or $15.4 billion when using a 7 percent discount rate). Of this total, $14.2 billion (or $13.4 billion) are the benefits of reduced premature mortality risk from PM exposure. Total monetized benefits are dominated by the benefits of reduced mortality risk, accounting for 87 percent of total monetized benefits, followed by chronic bronchitis totaling $1.8 billion, which represents 11 percent of the total. Following chronic bronchitis, minor restricted activity days (MRADs) is the next largest quantified benefit category totaling $100 million, and it also presents the category with the largest number of incidences at 1,942,340 per year. MRADs in combination with lost work days and avoided hospital admissions from cardiovascular-related illness account for $140 million of total benefits. For the asthma-related endpoints, we note that the MACT floor will result in approximately 173,000 fewer asthma attacks, more than 2,000 fewer visits to the emergency room of hospitals for asthma, and 200 fewer hospital admissions for asthma-related effects.

Total annual benefits of the above the MACT floor regulatory option are $17.2 billion under when using a 3 percent discount rate (or $16.3 billion when using a 7 percent discount rate). Similar to the MACT floor results, the mortality endpoint accounts for the majority of benefits at $15.1 billion (or $14.2 billion), followed by chronic bronchitis at $1.9 billion. MRADs account for $100 million in benefits and 2,064,854 fewer incidences. The monetized benefits of MRADs combined with lost work days and cardiovascular-related hospital admissions account for $180 million of benefits. For the asthma-related endpoints, we note that the above the MACT floor option will result in approximately 82,000 fewer asthma attacks, more than 2,000 fewer visits to the emergency room of hospitals for asthma, and about 240 fewer hospital admissions for asthma-related effects.

Table 10-14. Total Annual Benefits of the Industrial Boilers/Process Heaters NESHAP [A]

MACT Floor Regulatory Option

Endpoint	Avoided Incidence[B] (cases/year)	Monetary Benefits[C] (millions 1999$, adjusted for growth in real income)
Premature mortality[D] (long-term exposure, adults, 30 and over)		
-Using a 3% discount rate	2,270	$14,240
-Using a 7% discount rate	2,270	$13,375
Chronic bronchitis (adults, 26 and over, WTP valuation)	5,100	$1,835
Hospital Admissions – Pneumonia (adults, over 64)	1,100	$15
Hospital Admissions – COPD (adults, 64 and over)	900	$10
Hospital Admissions – Asthma (65 and younger)	230	<$5
Hospital Admissions – Cardiovascular (adults, over 64)	2,660	$50
Emergency Room Visits for Asthma (65 and younger)	2,040	<$1
Asthma Attacks (asthmatics, all ages)	173,490	B_1
Acute bronchitis (children, 8-12)	4,700	<$1
Lower respiratory symptoms (children, 7-14)	51,240	$1
Upper respiratory symptoms (asthmatic children, 10-11)	196,860	$5
Work loss days (adults, 18-65)	398,670	$40
Minor restricted activity days (adults, age 18-65)	1,942,340	$100
Other PM-related health effects[E]	U_1	B_2
HAP-related health effects[E]	U_2	B_3
Total Monetized Health-Related Benefits[F]		
-Using a 3% discount rate	—	$16,300+$\mathbf{B_H}$
-Using a 7% discount rate	—	$15,430+$\mathbf{B_H}$

[A] The results presented in this table include all emission reductions including those identified for specific sources included in the Inventory Database included in the Phase One analysis and the remaining reductions not included in the Inventory Database included in the Phase Two analysis

[B] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.

[C] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.

[D] The estimated value for PM-related premature mortality assumes a 5-year distributed lag structure and discounted at a 3% rate, which is described in the IAQR benefit anlaysis.

[E] A detailed listing of unquantified PM and HAP related health effects is provided in Table 10-16.

Table 10-15. Total Annual Benefits of the Industrial Boilers/Process Heaters NESHAP [A]
Above the MACT Floor Regulatory Option

Endpoint	Avoided Incidence[B] (cases/year)	Monetary Benefits[C] (millions 1999$, adjusted for growth in real income)
Premature mortality[D] (long-term exposure, adults, 30 and over)		
-Using a 3% discount rate	2,410	$15,135
-Using a 7% discount rate	2,410	$14,220
Chronic bronchitis (adults, 26 and over, WTP valuation)	5,220	$1,875
Hospital Admissions – Pneumonia (adults, over 64)	1,110	$15
Hospital Admissions – COPD (adults, 64 and over)	910	$10
Hospital Admissions – Asthma (65 and younger)	240	<$5
Hospital Admissions – Cardiovascular (adults, over 64)	2,680	$50
Emergency Room Visits for Asthma (65 and younger)	2,080	<$1
Asthma Attacks (asthmatics, all ages)	82,130	B_1
Acute bronchitis (children, 8-12)	4,970	<$1
Lower respiratory symptoms (children, 7-14)	54,190	$1
Upper respiratory symptoms (asthmatic children, 10-11)	200,590	$5
Work loss days (adults, 18-65)	275,710	$30
Minor restricted activity days (adults, age 18-65)	2,064,850	$100
Other PM-related health effects[E]	U_1	B_2
HAP-related health effects[E]	U_2	B_3
Total Monetized Health-Related Benefits		
-Using a 3% discount rate	—	$17,230+$\mathbf{B_H}$
-Using a 7% discount rate	—	$16,310+$\mathbf{B_H}$

[A] The results presented in this table include all emission reductions including those identified for specific sources included in the Inventory Database and the remaining reductions not included in the Inventory Database.
[B] Incidences are rounded to the nearest 10 and may not add due to rounding. Incidences of unquantified endpoints are indicated with a U.
[C] Dollar values are rounded to the nearest 5 million and may not add due to rounding. The value of unquantified endpoints are indicated with a B.
[D] The estimated value for PM-related premature mortality assumes a 5-year distributed lag structure and discounted at a 3% rate, which is described in the IAQR benefit anlaysis.
[E] A detailed listing of unquantified PM and HAP related health effects is provided in Table 10-16.

10.7 Limitations of the Analysis

10.7.1 *Uncertainties and Assumptions*

Significant uncertainties and potential biases are inherent in any benefits analysis based on benefits transfer techniques. This analysis uses two forms of benefit transfer, (1) the transfer of dose-response functions and valuation estimates from published articles, and (2) the transfer of value per ton reduced from the monetized estimate in the phase one analysis. The degree of uncertainty and bias depends on how divergent the reality of the policy situation is from the state of the world assumed in the benefits transfer approaches.

For this analysis, several key assumptions may lead to over or underestimation of benefits. Table 10-8 lists these assumptions, and where possible indicate the expected direction of the bias. This is by no means an exhaustive list, but captures what we have identified as key assumptions. In addition to these uncertainties and biases, there are uncertainties and biases embedded in the original benefits analyses from which the transfer values were generated. Some of these potential biases and assumptions are discussed in the preceding sections. For a full discussion of these uncertainties, see the RIA for the Heavy Duty Engine/Diesel Fuel rule, as well as the Section 812 report to congress on the Benefits and Costs of the Clean Air Act 1999 to 2010.

**Table 10-16.
Significant Uncertainties and Biases Associated with the
Industrial Boilers/Process Heaters Benefit Analysis**

Assumption	Direction of Bias[A]
Omission of HAP effects, and PM effects associated with visibility and materials damage benefit categories	Downward
Estimated emission reductions accurately reflect conditions in 2005	Unknown
Future meteorology well-represented by modeled meteorology	Unknown
Benefits from source studies do not include all benefits and disbenefits	Unknown
Population, demographics, exposures, and air quality included in phase one analysis is representative for the transfer to the phase two analysis	Unknown
Linear extrapolation of future populations	Unknown
Accuracy of S-R Matrix representativeness of secondary PM formation chemistry	Unknown

[A] A downward bias is an indicator that total benefits are underestimated. An upward bias is an indicator that total benefits are overestimated. In several cases, the direction of the bias is unknown and can potential be an underestimate or an overestimate of total benefits.

10.7.2 *Unquantified Effects*

In addition to the monetized benefits presented in the above tables, it is important to recognize that many benefit categories associated with HAP, SO_2, and PM reductions are not quantified or monetized for this analysis. With respect to the benefits of reducing exposure to HAPs, EPA has developed a rudimentary risk analysis focusing only on cancer risks. As discussed above, this analysis suggests that the rule would reduce cancer incidence by roughly tens of cases per year if it were implemented at all affected boiler and process heater facilities. Placing a value on these impacts would increase the economic benefits of the rule. This analysis carries significant assumptions, uncertainties, and limitations. EPA is working with the SAB to develop better methods for analyzing the cancer and non-cancer benefits of HAP reductions. EPA will include a monetized estimate of the benefits of reducing HAP emissions with the analysis for the final rule if it is able to develop better methods before promulgation of this rule. Other potentially important unquantified benefit categories are listed in Table 10-17. For a more complete discussion of unquantified benefits and disbenefits, see the RIA for the Heavy Duty Engine/Diesel Fuel rule.

Table 10-17. Unquantified Benefit Categories

	Unquantified Benefit Categories Associated with HAPs	Unquantified Benefit Categories Associated with PM
Health Categories	Airway responsiveness Pulmonary inflammation Increased susceptibility to respiratory infection Acute inflammation and respiratory cell damage Chronic respiratory damage/ Premature aging of lungs Emergency room visits for asthma	Changes in pulmonary function Morphological changes Altered host defense mechanisms Other chronic respiratory disease Emergency room visits for asthma Emergency room visits for non-asthma respiratory and cardiovascular causes Lower and upper respiratory symptoms Acute bronchitis Shortness of breath Increased school absence rates
Welfare Categories	Ecosystem and vegetation effects Damage to urban ornamentals (e.g.,grass, flowers, shrubs, and trees in urban areas) Commercial field crops Fruit and vegetable crops Reduced yields of tree seedlings, commercial and non-commercial forests Damage to ecosystems Materials damage	Materials damage Damage to ecosystems (e.g., acid sulfate deposition) Nitrates in drinking water Visibility in recreational and residential areas

10.8 Benefit-Cost Comparison

This Regulatory Impact Analysis (RIA) provides cost, economic impact, and benefit estimates that are potentially useful for evaluating regulatory alternatives for the industrial boilers and process heaters rule. Benefit-cost analysis provides a systematic framework for assessing and comparing such alternatives. According to economic theory, the efficient alternative maximizes net benefits to society (i.e., social benefits minus social costs). However, there are practical limitations for the comparison of benefits to costs in this analysis. In particular, the inability to quantify the primary HAP related benefits of the rule, as well as the inability to quantify the disbenefits of increased electricity generation related emissions introduces biases into our estimate of benefits that make comparison with costs less meaningful. Executive Order 12866 clearly indicates that unquantifiable or nonmonetizable categories of both costs and benefits should not be ignored. There are many important unquantified and unmonetized costs and benefits associated with reductions in PM_{10} and $PM_{2.5}$ emissions, including many health and welfare effects. Potential PM benefit categories that have not been quantified and monetized are listed in Table 10-18 of this chapter. It is also important to recall that this analysis is only of the monetizable benefits associated with PM_{10} and $PM_{2.5}$ reductions. The rule is designed to reduce HAP emissions. By achieving these HAP reductions, the rule reduces the risks associated with exposures to those chemicals, including the risk of fatal cancers. It is likely the monetized benefit estimates presented in this chapter are expected to underestimate total benefits of the rule.

In addition to categories that cannot be included in the calculated net benefits, there are also practical limitations for the comparison of benefits to costs in this analysis, which have been discussed throughout this chapter. Several specific limitations deserve to be mentioned again here:

- The state of atmospheric modeling is not sufficiently advanced to provide a workable "one atmosphere" model capable of characterizing ground-level pollutant exposure for all pollutants of interest (e.g., ozone, particulate matter, carbon monoxide, nitrogen deposition, etc). Therefore, the EPA must employ several different pollutant models to characterize the effects of alternative policies on relevant pollutants. Also, not all atmospheric models have been widely validated against actual ambient data. In particular, since a broad-scale monitoring network is in the early stages of development for fine particulate matter ($PM_{2.5}$), atmospheric models designed to capture the effects of alternative policies on $PM_{2.5}$ are not fully validated. Additionally, significant shortcomings exist in the data that are available to perform these analyses. While containing identifiable shortcomings and uncertainties, EPA believes the models and assumptions used in the analysis are reasonable based on the available data and evidence.

- Qualitative and more detailed discussions of the above and other uncertainties and limitations are included in detail in earlier sections. In particular, the fact that only half of the sources expected to be affected by this rule are actually covered in these analysis contributes to the uncertainty of the benefits estimates (as well those of the costs and economic impacts, as well). Data limitations prevent an overall quantitative estimate of the uncertainty associated with final estimates. Nevertheless, the reader should keep all of these uncertainties and limitations in mind when reviewing and interpreting the results.

- The PM benefit estimates do not include the monetary value of several known PM-related welfare effects, including recreational and residential visibility, household soiling, and materials damage.

Nonetheless, if one is mindful of these limitations, the relative magnitude of the benefit-cost comparison presented here can be useful information. Thus, this section summarizes the benefit and cost estimates that are potentially useful for evaluating the efficiency of the Industrial Boilers and Process Heaters rule.

The estimated social cost of implementing the NESHAP at the MACT floor is approximately $837 million (1999$) in third year after issuance of this rule. The monetized benefits of the MACT floor are $16.3 billion when using a 3 percent discount rate (or approximately $15.4 billion when using a 7 percent discount rate). Keeping in mind that no primary HAP-related benefits are quantified, comparison with costs indicates that our estimate of monetized benefits of ancillary PM_{10} and SO_2 reductions alone exceed the compliance costs by nearly a factor of 20.

For the above the floor option (also called "Option 1A" in this RIA), the estimated social cost is $1.9 billion (1999$) in third year after issuance of this rule. The monetized benefits of the above the floor option are $17.2 billion when using a 3 percent discount rate (or approximately $16.3 billion when using a 7 percent discount rate). Thus, our estimate of benefits of the above the floor option exceed the costs by a factor of 8.

It is also useful to consider the incremental costs and benefits of moving from the MACT floor to the above the floor option. The incremental net benefits of going to the above the floor option from the NESHAP (the MACT floor alternative) is -$160 million (using a 3 percent discount rate). Hence, the final rule can be considered a more efficient alternative to society than the above the floor option from the standpoint of maximizing net benefits. Note that while monetized benefits of PM_{10} and SO_2 reductions are large in this instance, they account for only a portion of the benefits of this rule. Notable omissions include all benefits of HAPs and VOC reductions, including reduced cancer incidences, central nervous system and cardiovascular system effects, and ozone related benefits. It is also important to note that not all benefits of PM_{10} reductions have been monetized. Categories which have contributed significantly to monetized benefits in past analyses (see the Heavy Duty Engine/Diesel Fuel RIA) include recreational and residential visibility and household soiling. Table 10-17 lists known unquantified benefits associated with PM and HAP reductions. Table 10-18 summarizes the costs, benefits, and net benefits for the rule and the above the floor option, and shows a comparison of the two options.

We did not attempt to estimate welfare benefits associated with PM reductions for this rule because of the difficulty in developing acceptable benefit transfer values for these effects. The SAB has recently reviewed existing studies valuing improvements in residential visibility and reductions in household soiling and advised that these studies do not provide an adequate basis for valuing these effects in cost-benefit analyses (EPA-SAB-COUNCIL-ADV-00-002, 1999; EPA-SAB-Council-ADV-003, 1998). Reliable methods do exist for valuing visibility improvements in Federal Class I areas, however, the benefits transfer method outlined above does not allow for predictions of changes in visibility at specific Class I areas. These predictions are necessary to estimate Class I area visibility benefits. As such we have left this potentially important endpoint unquantified for this analysis. Given the proximity of some sources to national parks in the Northwest (Mt. Ranier, Olympic, and Crater Lake), Northern Rockies (Glacier), and Maine (Acadia), these omitted benefits may be significant.

As we characterize the comparison of benefits to costs, it should be recognized that the Agency believes its risk-based approach to regulating HCl and Mn emissions from industrial boilers will reduce the cost impact of this final MACT standard while still achieving substantial reduction in HCl and Mn exposure by affected populations. In offering this approach, the Agency recognizes that there may be foregone benefits associated in excess of the resulting reduction in costs. As is discussed in earlier in the RIA, the Agency is not able to quantify the benefits of HAP reductions. However, the reduction in HCl and Mn benefits are not anticipated to be substantial based on the description of potential effects described in Chapter 9 of this RIA. The acid gas scrubbers installed by industrial boilers not only reduce HCl emissions but also sulfur dioxide (SO_2) emissions simultaneously. Reduction of SO_2 emissions can provide large monetized benefits since it is a precursor of fine particulate matter ($PM_{2.5}$), a pollutant associated with a high degree of premature mortality in exposed populations. The fabric filters installed by industrial boilers not only reduce Mn emissions but also PM emissions simultaneously. Reduction of directly emitted coarse particulate matter (PM_{10}) emissions can also provide large monetized benefits as well. While there may be foregone benefits in excess of the cost reduction, it should be recognized that the estimated monetized benefits from implementation of the final rule including this risk-based approach are still much larger than the costs ($14.5 billion versus $690 million, or greater by a factor of 21). In addition, it should be recognized that the reductions not achieved due to industrial boilers taking advantage of the risk-based approach could be obtained in a more efficient manner through other regulatory programs to reduce PM. More information on comparing the benefits of this rule to its costs can be found earlier in this RIA chapter.

The Agency recognizes that many States will want to reduce SO_2 and PM emissions from current levels in order to meet requirements associated with the proposed Interstate Air Quality Rule (IAQR) and PM National Ambient Air Quality Standards (NAAQS). It may be necessary for States to require reductions of SO_2 in higher amounts than can be obtained from the venturi scrubbers or PM reductions from fabric filters that would be required to meet this final MACT standard. The Agency understands that it would be difficult for States to justify requiring industrial boilers to dismantle scrubbers and fabric filters installed to comply with the MACT standard in order to install more expensive ones that meet potentially more stringent SO_2 and PM control requirements associated with implementation of the IAQR and PM NAAQS. The Agency will work carefully with States to help them minimize the potential "stranded investment" by industrial boiler owners in venturi scrubbers that may result as State agencies develop SIPs to meet the IAQR and PM NAAQS.

Table 10-18. Annual Net Benefits of the Industrial Boilers and Process Heaters NESHAP in 2005

	MACT Floor (Million 1999$)	Above the MACT Floor (Million 1999$)
Social Costs[B]	$837	$1,923
Social Benefits[B, C, D]:		
HAP-related health and welfare benefits	Not monetized	Not monetized
PM-related welfare benefits	Not monetized	Not monetized
SO2- and PM-related health benefits:		
-Using 3% Discount Rate	$16,300 + B	$17,230 + B
-Using 7% Discount Rate	$15,430 + B	$16,310 + B
Net Benefits (Benefits - Costs)[C, D]:		
-Using 3% Discount Rate	$15,465	$15,305 + B
-Using 7% Discount Rate	$14,595	$14,385 + B

[A] All costs and benefits are rounded to the nearest $5 million. Thus, figures presented in this table may not exactly equal benefit and cost numbers presented in earlier sections of the chapter.
[B] Note that costs are the total costs of reducing all pollutants, including HAPs as well as SO_2 and PM_{10}. Benefits in this table are associated only with PM and SO_2 reductions.
[C] Not all possible benefits or disbenefits are quantified and monetized in this analysis. Potential benefit categories that have not been quantified and monetized are listed in Table 8-13. B is the sum of all unquantified benefits and disbenefits.
[D] Monetized benefits are presented using two different discount rates. Results calculated using 3 percent discount rate are recommended by EPA's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a). Results calculated using 7 percent discount rate are recommended by OMB Circular A-94 (OMB, 1992).

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APPENDIX A:
ECONOMIC MODEL OF MARKETS AFFECTED BY THE BOILERS AND PROCESS HEATERS MACT

The primary purpose of the EIA for the final rule is to describe and quantify the economic impacts associated with the rule. The Agency used a basic framework that is consistent with economic theory and the analyses performed for other rules to develop estimates of these impacts. This approach employs standard microeconomic concepts to model behavioral responses expected to occur with regulation. This appendix describes the spreadsheet model in more detail and discusses how the Agency

- collected the baseline data set from the Annual Energy Outlook 2002 (DOE, EIA, 2002), U.S. Census Bureau (U.S. Department of Commerce, 2001), and U.S. Department of Agriculture (USDA, 2002).

- characterized market supply and demand for each market and specified links between the energy and agricultural, manufacturing, mining, and commercial markets.

- introduced a policy "shock" into the model by using control cost-induced shifts in the supply functions, and

- used a solution algorithm to determine a new with-regulation equilibrium for each market.

A.1 Baseline Data Set

EPA collected the following data to characterize the baseline year, 2005:

- *Energy Market Data*—The Department of Energy's Supplemental Tables to the Annual Energy Outlook 2002 report forecasts of price, quantity, and fuel intensities used to calibrate the model.
- *Agriculture, Mining, Manufacturing, Commercial Sectors*—EPA obtained shipment data from the 1997 Economic Census and 1997 Agriculture Census. We then used annual growth rates reported by the Bureau of Economic Analysis (BEA, 1997) to estimate baseline shipment data for 2005. The Agency selected units for output such that the price in each market equals one. We computed energy demand using fuel intensity data reported in the AEO 2002.
- *Supply and Demand Elasticities*—The supply and demand elasticity values used in the market model are reported in Table 5-2 of this report. Given the uncertainties regarding these parameters, EPA also conducted several sensitivity analyses and report these results in Appendix B.

A.2 Multi-Market Model

The model includes four energy markets (coal, electricity, natural gas, and petroleum) and 24 goods and service markets. The following sections describe model equations the Agency developed to characterize these markets and estimate welfare changes resulting from the rule.

A.1.1 Supply Side Modeling

EPA estimated the change in quantity supplied as follows:

$$\Delta q^S = q_0^S \cdot \varepsilon^S \cdot \frac{\Delta p - c - \sum_{j=1}^{n} \alpha_j \Delta p_j}{p_0} \tag{A.1}$$

where q_0^S is the baseline quantity, ε^S is the domestic supply elasticity, the term $\Delta p - c - \sum_{j=1}^{n} \alpha_j \Delta p_j$ is the change in the producer's net price, and p_0 is the baseline price. The change in net price is composed of the change in baseline price resulting from the regulation, the direct shift in the supply function resulting from compliance costs, and the indirect shift in the supply function resulting from changes in input prices in energy market (j). The fuel share is allowed to vary using a fuel switching rule relying on cross-price elasticities of demand between energy sources.

A.1.1.2 Producer Welfare Measurement

EPA approximated the change in producer surplus with the following equation:

Increased control costs, higher energy input costs, and output declines have a negative

$$\Delta PS = q_1 \cdot (\Delta p - c - \sum_{j=1}^{n} \alpha_j \Delta p_j) - 0.5 \cdot \Delta q \cdot (\Delta p - c - \sum_{j=1}^{n} \alpha_j \Delta p_j) \tag{A.2}$$

effect on domestic producer surplus. However, these losses are mitigated to some degree as a result of higher market prices.

A.1.2 Energy Demand Side Modeling

Market demand in the energy markets is expressed as the sum of the energy, residential, agriculture, manufacturing, mining, commercial, and transportation sectors:

$$Q_{Dj} = \sum_{i=1}^{n} q_{Dji} \, , \tag{A.3}$$

where j indexes the energy market and i indexes the consuming sector. The change in residential quantity demanded of energy market j can be approximated as follows:

$$\Delta q^{D_j} = q_0^{D_j} \cdot \eta^{D_j} \cdot \frac{\Delta p_j}{p_{j0}} \tag{A.4}$$

where $q_0^{D_j}$ is baseline consumption, η^{Dj} is the residential demand elasticity and (Δp) is the change in the market price.

In contrast, energy demand from energy, agricultural, manufacturing, mining, commercial, and transportation sectors is modeled as a derived demand resulting from the production and consumption choices in these industries. Energy demand responds to changes in sector output and fuel switching that occurs in response to changes in relative energy prices. For each of these sectors, energy demand is expressed as follows:

$$BTU_{ji1} = \frac{BTU_{ji}}{q_{i0}} \cdot FSW \cdot q_{i1} \tag{A.5}$$

where BTU is demand for energy market j from sector i, q is sector i's output, and FSW is a factor generated by the fuel switching algorithm. The subscripts 0 and 1 represent baseline and with regulation conditions, respectively.

A.1.3 Agriculture, Manufacturing, Mining, Commercial, and Transportation Demand Side Modeling

The change in quantity demanded in these markets can be approximated as follows:

$$\Delta q^{D_i} = q_0^{D_i} \cdot \eta^{D_i} \cdot \frac{\Delta p_i}{p_{i0}} \tag{A.6}$$

where $q_0^{D_i}$ is baseline output, η^D is the demand elasticity of the respective market (i) and (Δ p_i) is the change in the market price.

The change in consumer surplus in markets is approximated as follows:
As shown, higher market prices and reduced consumption lead to welfare losses for consumers.

$$\Delta CS = - q_1 \cdot \Delta p + 0.5 \cdot \Delta q \cdot \Delta p \tag{A.7}$$

A.2 With-Regulation Market Equilibrium Determination

Market adjustments can be conceptualized as an interactive feedback process. Supply segments face increased production costs as a result of the rule and are willing to supply smaller quantities at the baseline price. This reduction in market supply leads to an increase in the market price that all producers and consumers face, which leads to further responses by producers and consumers and thus new market prices. The new with-regulation equilibrium is the result of a series of iterations in which price is adjusted and producers and consumers respond, until a set of stable market prices arises where total market supply equals market demand (i.e., $Qs = Q_D$) in each market. Market price adjustment takes place based on a price revision rule that adjusts price upward (downward) by a given percentage in response to excess demand (excess supply).

The algorithm for determining with-regulation equilibria can be summarized by seven recursive steps:

1. Impose the control costs on affected supply segments, thereby affecting their supply decisions.

2. Recalculate the market supply in each market. Excess demand currently exists.

3. Determine the new prices via a price revision rule.

4. Recalculate market supply with new prices, accounting for fuel switching choices associated with new energy prices.

5. Compute market demand in each market.

6. Compare supply and demand in each markets. If equilibrium conditions are not satisfied, go to Step 3, resulting in a new set of market prices. Repeat until equilibrium conditions are satisfied (i.e., the ratio of supply to demand is arbitrarily close to one).

APPENDIX B
ASSUMPTIONS AND SENSITIVITY ANALYSIS

In developing the economic model to estimate the impacts of the industrial/ commercial/institutional boilers and process heaters NESHAP, several assumptions were necessary to make the model operational. This appendix lists and explains the major model assumptions and describes their potential impact on the analysis results. Sensitivity analyses are presented for numeric assumptions.

Assumption: The domestic markets for goods and services are all perfectly competitive.
Explanation: Assuming that these markets are perfectly competitive implies that the producers of these products are unable to unilaterally affect the prices they receive for their products. Because the industries used in this analysis are aggregated across a large number of individual producers, it is a reasonable assumption that the individual producers have a very small share of industry sales and cannot individually influence the price of output from that industry.
Possible Impact: If these product markets were in fact imperfectly competitive, implying that individual producers can exercise market power and thus affect the prices they receive for their products, then the economic model would understate possible increases in the price of final products due to the regulation as well as the social costs of the regulation. Under imperfect competition, producers would be able to pass along more of the costs of the regulation to consumers; thus, consumer surplus losses would be greater, and producer surplus losses would be smaller in the final product markets.
Assumption: Market Supply and Demand Elasticity Uncertainty
Explanation: The goods and service markets are modeled at the two or three-digit NAICS code level to operationalize the economic model. Because of the high level of aggregation, only limited data on elasticities of supply and demand estimates are available. However, these elasticities strongly influence the distribution of economic impacts between producers and consumers.

Sensitivity Analysis: Tables B-1a and Table B-1b show how the economic impact estimates vary as the supply and demand elasticities for goods and services change by 25 percent.

Table B-1a. Sensitivity Analysis: Supply and Demand Elasticities in the Goods and Services Markets

Change Supply Demand Constant	25% Decrease	Elasticities Reported in Section 6	25% Increase
Change in consumer surplus	–367.8	–414.3	–450.5
Change in producer surplus	–495.2	–448.7	–412.4
Change in social welfare	–862.9	–862.9	–862.9

Assumption: Cross-price elasticities of demand for fuels are based on 2015 NEMS projections.
Explanation: Cross- and own-price elasticities of demand from NEMS were used to capture fuel switching in the manufacturing sectors in the economic model. As shown in Table 5-2, allowing manufacturers to switch fuels in response to changes in relative energy prices decreases the change in

Table B-1b. Sensitivity Analysis: Supply and Demand Elasticities in the Goods and Services Markets

Supply Constant Demand Change	25% Decrease	Elasticities Reported in Section 6	25% Increase
Change in consumer surplus	–462.7	–414.3	–364.4
Change in producer surplus	–400.2	–448.7	–498.5
Change in social welfare	–862.9	–862.9	–862.9

social welfare by approximately 10 percent. However, the NEMS projection reflects aggregate behavioral responses in the year 2015. Because this is a longer window of analysis compared to the baseline year 2005, this analysis may overestimate firms' ability to switch fuels in the short run.
Sensitivity Analysis: Table B-2 shows how the economic impact estimates vary as the own- and cross-price elasticities used in the EIA are reduced by 50 percent and 75 percent.

Table B-2. Sensitivity Analysis: Own- and Cross-Price Elasticities Used to Model Fuel Switching

	Fuel Price Elasticities Presented in Table 5-2	Reduced by 50 Percent	Reduced by 75 Percent
Change in consumer surplus	–414.3	–414.6	–414.9
Change in producer surplus	–448.7	–448.4	–448.0
Change in social welfare	–862.9	–862.9	–862.9

Assumption: The domestic markets for energy are perfectly competitive.
Explanation: Assuming that the markets for energy are perfectly competitive implies that individual producers are not capable of unilaterally affecting the prices they receive for their products. Under perfect competition, firms that raise their price above the competitive price are unable to sell at that higher price because they are a small share of the market and consumers can easily buy from one of a multitude of other firms that are selling at the competitive price level. Given the relatively homogeneous nature of individual energy products (petroleum, coal, natural gas, electricity), the assumption of perfect competition at the national level seems to be appropriate.
Possible Impact: If energy markets were in fact imperfectly competitive, implying that individual producers can exercise market power and thus affect the prices they receive for their products, then the economic model would understate possible increases in the price of energy due to the regulation as well as the social costs of the regulation. Under imperfect competition, energy producers would be able to pass along more of the costs of the regulation to consumers; thus, consumer surplus losses would be greater, and producer surplus losses would be smaller in the energy markets.
Assumption: The elasticity of supply in the electricity market for existing sources is approximately 0.75.
Explanation: The price elasticity of supply in the electricity markets represents the behavioral responses from existing sources to changes in the price of electricity. However, there is no consensus on estimates of the price elasticity of supply for electricity. This is in part because, under traditional regulation, the electric utility industry had a mandate to serve all its customers and utilities were compensated on a rate-based rate of return. As a result, the market concept of supply elasticity was not the driving force in utilities' capital investment decisions. This has changed under deregulation. The market price for electricity has become the determining factor in decisions to retire older units or to make higher cost units available to the market.
***Sensitivity Analysis*:** Table B-3 shows how the economic impact estimates vary as the elasticity of supply in the electricity markets varies.

Table B-3. Sensitivity Analysis: Elasticity of Supply in the Electricity Markets

	ES = 0.5	ES = 0.75	ES = 1.0
Change in consumer surplus	–405.0	–414.3	–419.6
Change in producer surplus	–457.9	–448.7	–443.4
Change in social welfare	–862.9	–862.9	–862.9

Appendix C

Air Quality Changes for the Above-the-Floor Option (Option 1A)

Table C-1 summarizes the baseline PM_{10}, $PM_{2.5}$, and SO_2 emissions and emission reductions nationwide for the MACT floor option. The air quality analysis presumes no change in volatile organic compound (VOC), nitrogen oxides (NOx), carbon monoxide (CO), and ammonia (NH_3) emissions. Hence, the baseline emissions for these pollutants are not shown in this table. For these baseline emissions, refer to Pechan, 2001.

Table C-1. Summary of Nationwide Baseline Emissions and Emission Reductions[a] for the MACT floor (in tons/year), Existing Units Only[b,c] in 2005

Pollutant	Source Type	1996 Baseline Emissions (tons/year)	Unknown Affected Units	Option 1A Emission Reductions Known Affected Units / Unknown Affected Units / Total Affected Units
SO_2				
	Point	3,745,790	30,394	95,361 41,372 136,733
	Area	1,397,425		
	Motor Vehicle	302,938		
	Nonroad	840,167		
PM_{10}				
	Point	1,167,995	298,109	313,947 255,282 569,229

	Area	30,771,607		
	Motor Vehicle	294,764		
	Nonroad	463,579		
$PM_{2.5}$				
	Point	576,022	84,125	94,565 76,894 171,459
	Area	6,675,777		
	Motor Vehicle	230,684		
	Nonroad	410,334		

As mentioned in Chapter 8 of this RIA, we conducted no air quality modeling for the HAP or the mercury emission reductions that occur from the potential implementation of Option 1A. These emission reductions are listed in Table C-2. For a description of how HAP emissions and emission factors are estimated for this rule, refer to the emission factors/emissions estimates memo in the public docket (ERG, 2002).

Table C-2. HAP Emission Reductions for Option 1A, 2005
Existing Sources Only

Pollutant	Emission Reductions (tons/year) Option 1A
HCl	40,406
Pb	105
Hg	2.2
Non-mercury metals[a]	1,135
Selected inorganics[b]	18,250
Total HAP reductions	59,190

[a]Non-mercury metals include: arsenic, beryllium, cadmium, chromium, manganese, and nickel.
[b]Selected inorganics include: chlorine, hydrofluoric acid, and phosphorus.

Table C-3 provides a summary of the predicted ambient PM_{10} and $PM_{2.5}$ concentrations from the S-R matrix for the 2005 baseline and changes associated with Option 1A, the above-the-MACT floor examined in this RIA. The results indicate that the predicted change in PM concentrations is composed almost entirely of reductions in fine particulates ($PM_{2.5}$) with little or no reduction in coarse particles (PM_{10} less $PM_{2.5}$). Therefore, the observed changes in PM_{10} are composed primarily of changes in $PM_{2.5}$. These results are quite similar to those for the final rule (MACT floor option). In addition to the standard frequency statistics (e.g., minimum, maximum, average, median), Table C-3 provides the population-weighted average which better reflects the baseline levels and predicted changes for more populated areas of the nation. This measure, therefore, will better reflect the potential benefits of these predicted changes through exposure changes to these populations. As shown, the average annual mean concentrations of $PM_{2.5}$ across all U.S. grid-cells declines by roughly 0.9 percent, or 0.10 µg/m^3. The population-weighted average mean concentration declined by 0.9 percent, or 0.12 µg/m^3, which is slightly larger in absolute terms than the spatial average. This indicates that the above-the-floor option generates slightly greater absolute air quality improvements in more populated, urban areas than in less populated, rural areas.

Table C-3.
Summary of 2005 Base Case PM Air Quality and Changes Due to MACT Above-the-Floor Option: Industrial Boiler/Process Heater Source Categories

Statistic	*2005 Baseline*	*Change*[a]	*Percent Change*
PM_{10}			
Minimum Annual Mean (µg/m^3) [b]	6.09	-0.08	-1.3%
Maximum Annual Mean (µg/m^3) [b]	69.30	-0.03	-0.1%
Average Annual Mean (µg/m^3)	22.68	-0.36	-1.6%
Median Annual Mean (µg/m^3)	21.84	-0.43	-1.9%
Population-Weighted Average Annual Mean (µg/m^3) [c]	28.79	-0.38	-1.3%
$PM_{2.5}$			
Minimum Annual Mean (µg/m^3) [b]	0.74	-0.01	0.0%
Maximum Annual Mean (µg/m^3) [b]	30.35	-0.77	-2.5%
Average Annual Mean (µg/m^3)	11.15	-0.10	-0.9%
Median Annual Mean (µg/m^3)	11.11	-0.13	-1.2%
Population-Weighted Average Annual Mean (µg/m^3) [c]	13.50	-0.12	-0.9%

[a] The change is defined as the control case value minus the baseline value.
[b] The baseline minimum (maximum) is the value for the populated county with the lowest (highest) annual average. The change relative to the baseline is the observed change for the populated county with the lowest (highest) annual average in the baseline.
[c] Calculated by summing the product of the projected 2005 county population and the estimated 2005 PM concentration for that county, and then dividing by the total population in the 48 contiguous States.

Table C-4 provides information on the 2005 populations that will experience improved PM air quality under the above-the-floor option. There are also fairly significant populations that live in areas with meaningful reductions in annual mean $PM_{2.5}$ concentrations resulting from the above-the-floor option, though the increment of reduction between the above-the-floor option and the MACT floor option is quite small. As shown, about 1 percent of the 2005 continental U.S. population are predicted to experience reductions of greater than 1 µg/m^3. Furthermore, about 4 percent of the 2005 U.S. population will benefit from reductions in annual mean $PM_{2.5}$ concentrations of greater than 0.5 μg/m^3 and about 38 percent will live in areas with reductions of greater than 0.1 μg/m^3.

Table C-4.
Distribution of PM2.5 Air Quality Improvements Over 2005 Population Due to MACT Above-the-Floor Option: Industrial Boiler/Process Heater Source Categories

Change in Annual Mean $PM_{2.5}$ Concentrations (μg/m^3)	*2005 Population*	
	Number (millions)	*Percent (%)*
Δ $PM_{2.5}$ Conc = 0	34.3	12.1%
0 > Δ $PM_{2.5}$ Conc ≤ 0.05	86.4	30.5%
0.05 > Δ $PM_{2.5}$ Conc ≤ 0.1	56.5	19.9%
0.1 > Δ $PM_{2.5}$ Conc ≤ 0.25	77.2	27.3%
0.25 > Δ $PM_{2.5}$ Conc ≤ 0.5	18.1	6.4%
0.5 > Δ $PM_{2.5}$ Conc ≤ 1.0	8.6	3.0%
1.0 > Δ $PM_{2.5}$ Conc ≤ 2.0	2.0	0.7%
Δ $PM_{2.5}$ Conc > 2.0	0.2	0.1%

[a] The change is defined as the control case value minus the baseline value.

Table C-5.
Summary of Absolute and Relative Changes in PM Air Quality Due to MACT Above-the-Floor Option: Industrial Boiler/Process Heater Source Categories

Statistic	*PM_{10} Annual Mean*	*$PM_{2.5}$ Annual Mean*
Absolute Change from 2005 Baseline ($\mu g/m^3$)[a]		
Minimum	0.00	0.00
Maximum	-19.20	-6.09
Average	-0.36	-0.10
Median	-0.20	-0.07
Population-Weighted Average [c]	-0.38	-0.12
Relative Change from 2005 Baseline (%)[b]		
Minimum	0.00%	0.00%
Maximum	-58.34%	-38.47%
Average	-1.52%	-0.85%
Median	-0.94%	-0.65%
Population-Weighted Average [c]	-1.46%	-0.87%

[a] The absolute change is defined as the control case value minus the baseline value for each county.

[b] The relative change is defined as the absolute change divided by the baseline value, or the percentage change, for each county. The information reported in this section does not necessarily reflect the same county as is portrayed in the absolute change section.

[c] Calculated by summing the product of the projected 2005 county population and the estimated 2005 county PM absolute/relative measure of change, and then dividing by the total population in the 48 contiguous states.

Table C-5 provides additional insights on the changes in PM air quality resulting from the above-the-floor option. The information presented previously in Table 8-6 illustrated the absolute and relative changes for different points along the distribution of baseline 2005 PM concentration levels, e.g., the change reflects the lowering of the minimum predicted baseline concentration rather than the minimum predicted change for 2005. The latter is the focus of Table C-5 as it presents the distribution of predicted changes in both absolute terms (i.e., $\mu g/m^3$) and relative terms (i.e., percent) across individual grid-cells. Therefore, it provide more information on the range of predicted changes that as shown, the absolute reduction in annual mean PM_{10} concentration ranged from a low of 0.00 $\mu g/m^3$ to a high of 19.20 $\mu g/m^3$, while the relative reduction ranged from a low of 0.0 percent to a high of 58.5 percent. Alternatively, for mean $PM_{2.5}$, the absolute reduction ranged from 0.00 to 6.09 $\mu g/m^3$, while the relative reduction ranged from 0.0 to 38.5 percent.

Comparison of Air Quality Changes for the MACT Floor and Above The Floor Options

The increment in air quality improvements between the above the floor option and the MACT floor option (the final rule) in 2005 is quite small as seen in a comparison between the results for each option. There is only a 0.01 $\mu g/m^3$ decrease in nationwide average annual mean $PM_{2.5}$ concentration for the above-the-floor option compared to the MACT floor option, and a 0.04 $\mu g/m^3$ decrease in average annual mean PM_{10} concentration. In addition, the differences in the nationwide population-weighted average annual mean are 0.02 $\mu g/m^3$ for $PM_{2.5}$ and 0.05 $\mu g/m^3$ for PM_{10} concentrations. Hence, the difference in air quality improvement between the options is small. The improvements in air quality is one possible component of choosing between a MACT floor option and an above the floor option.

Visibility Improvements

Table C-6 provides the distribution of visibility improvements across the 2005 U.S. population resulting from the above-the-floor MACT option. The majority of the 2005 U.S. population live in areas with predicted improvement in annual average visibility of between 0 to 0.1 deciviews. As shown, 5 percent of the 2005 U.S. population are predicted to experience improved annual average visibility of greater than 0.25 deciviews. Furthermore, just over 80 percent of the 2005 U.S. population will benefit from an improvement in visibility, i.e., change in deciview greater than zero.

Table C-6.
Distribution of Populations Experiencing Visibility Improvements in 2005 Due to MACT Above-the-Floor Option: Industrial Boiler/Process Heater Source Categories

Improvements in Visibility [a] *(annual average deciviews)*	*2005 Population*	
	Number (millions)	*Percent (%)*
Δ *Deciview* = 0	50.2	17.7%
0 > Δ *Deciview* ≤ 0.05	152.5	53.9%
0.05 > Δ *Deciview* ≤ 0.1	55.8	19.7%
0.1 > Δ *Deciview* ≤ 0.15	10.5	3.7%
0.15 > Δ *Deciview* ≤ 0.25	10.2	3.6%
0.25 > Δ *Deciview* ≤ 0.5	2.8	1.0%
Δ *Deciview* > 0.5	1.1	0.4%

[a] The change is defined as the MACT Above-the-Floor control case deciview level minus the base case deciview level.

Residential Visibility

For the above-the-floor option, the air quality modeling results predict slightly greater improvements in visibility through the country than for the MACT floor option. In Table C-7, we summarize residential visibility improvements across the Eastern and Western U.S. in 2005 that result from the above-the-floor MACT option. The baseline annual average visibility for all U.S. counties in the contiguous 48 States is 14.8 deciviews. The mean improvement across these U.S. counties is 0.05 deciviews, or almost 0.2 percent. In urban areas with a population of 250,000 or more (i.e., 819 out of 3,080 counties), the mean improvement in annual visibility was 0.06 deciviews and ranged from 0.01 to 0.98 deciviews. In rural areas (i.e., 2,261 counties), the mean improvement in visibility was 0.05 deciviews in 2005 and ranged from 0.01 to 0.52 deciviews.

On average, the Eastern U.S. experienced larger absolute and relative improvements in visibility than the Western U.S. from the industrial boilers and process heaters reductions. In Eastern U.S., the mean improvement was 0.06 deciviews from an average baseline of 22 deciviews. Western counties experienced a mean improvement of 0.01 deciviews from an average baseline of 17.82 deciviews projected in 2005. Overall, the data suggest that the rule provides slight improvements in visibility for 2005.

Table C-7.
Summary of 2005 Baseline Visibility and Changes by Region Due to MACT Above-the-Floor Option: Residential(Annual Average Deciviews)

Regions[a]	*2005 Baseline*	*Change*[b]	*Percent Change*
Eastern U.S.	22.00	-0.06	-0.2%
Urban	22.95	-0.07	-0.3%
Rural	21.62	-0.06	-0.2%
Western U.S.	17.82	-0.01	-0.1%
Urban	19.19	-0.01	-0.1%
Rural	17.55	-0.01	-0.1%
National, all counties	21.19	-0.05	-0.2%
Urban	22.49	-0.06	-0.3%
Rural	20.72	-0.04	-0.2%

[a] Eastern and Western regions are separated by 100 degrees West longitude. Background visibility conditions differ by region.
[b] An improvement in visibility is a decrease in deciview value. The change is defined as the MACT Above-the-Floor control case deciview level minus the baseline deciview level

Recreational Visibility

In Table C-8, we summarize recreational visibility improvements resulting from the Above-the-Floor MACT option in 2005 for Federal Class I areas by region. These recreational visibility regions are the same ones as those in Figure 8-1 in Chapter 8 of the RIA. As shown, the national improvement in visibility for these areas is 0.3 percent, or 0.05 deciviews. Predicted relative visibility improvements are the largest in the Southeast (0.3%) and Northeast/Midwest (0.2%). These improvements are only slightly greater than those estimated for the MACT floor option. California was predicted to have no visibility improvements in Class I areas within that state.

Table C-8.
Summary of 2005 Baseline Visibility and Changes by Region Due to MACT Above-the-Floor Option: Recreational (Annual Average Deciviews)

Class I Visibility Regions[a]	*2005 Baseline*	*Change*[b]	*Percent Change*
Southeast	21.49	-0.07	-0.3%
Southwest	17.18	-0.01	-0.1%
California	19.86	0.00	0.0%
Northeast/Midwest	20.64	-0.06	-0.2%
Rocky Mountain	17.29	-0.02	-0.1%
Northwest	20.62	-0.03	-0.1%
National Average (unweighted)	19.17	-0.05	-0.3%

[a] Regions are pictured in Figure 8-1 and are defined in the technical support document for the air quality analysis.
[b] An improvement in visibility is a decrease in deciview value. The change is defined as the MACT Above-the-Floor control case deciview level minus the baseline deciview level.

APPENDIX D:
Derivation of Quantified Benefits

As Chapter 10 of this RIA explains, the benefit analysis of the Industrial Boilers/Process Heaters NESHAP entails two phases of analysis. These results reflect the use of two different discount rates to value reduced incidences of mortality; a 3% rate which is recommended by EPA's Guidelines for Preparing Economic Analyses (US EPA, 2000a), and 7% which is recommended by OMB Circular A-94 (OMB, 1992). In phase one, we modeled approximately 50 percent of the estimated emission reductions of SO2 and PM in an air quality model (the SR Matrix) and a benefit valuation model (the CAPMS model). This appendix provides tables that detail the steps necessary to derive the total benefits of the NESHAP.

Tables D-1 to D-4 show the benefits estimation for the MACT floor. Table D-1(a) shows the results of the phase one analysis when we modeled SO2 emission reductions alone. Given a total benefit estimate of $1.7 billion from the assessment of benefits for 85,542 tons of SO2 reduced out of a total estimated reduction of 112,936 tons, we then calculate a coefficient for each benefit endpoint to derive benefit transfer values for (1) incidence per ton reduced, and (2) benefit per ton reduced.

Table D-1(b) shows the results of phase two of the analysis associated with SO2 reductions. Using the benefit transfer values for incidence and value, we calculate the approximate benefits of the remaining 30,394 tons of SO2 out of the total 112,936 tons. Multiplying the total benefit per ton from Table D-1(a) of $20,028 to the 30,394 tons SO2 yields total benefits of the phase two analysis for SO2 of $609 million.

Tables D-2(a) and D-2(b) present results of the phase one and phase two analysis for the expected 562,110 tons of PM reduced due to the MACT Floor regulatory option of the NESHAP. The phase one analysis of PM reductions (Table D-2(a)) results in total benefits of $6.6 billion for 265,155 tons of PM10 and 75,095 tons of PM2.5. The resulting total benefit transfer value is $88,118 per ton of PM. Applying the benefit transfer values to the remaining 296,955 tons of PM results in total phase two benefits of approximately $7.4 billion.

Tables D-3(a) and D-3(b) show the summary of results of the phase one and phase two analysis for the combination of SO2 and PM reductions. Then Table D-4 aggregates the results of the two phases for all pollutant reductions to provided an estimate of the total benefits of the Industrial Boilers/Process Heaters NESHAP under the MACT Floor regulatory option in 2005 equal to $16.3 billion.

Tables D-5 to D-8 show the estimate of benefits for the above the MACT floor regulatory option. Table D-5(a) shows the results of the phase one analysis when we modeled SO2 emission reductions alone. Given a total benefit estimate of $2.1 billion from the assessment of benefits of 95,361 tons of SO2 reduced out of a total estimated reduction of 136,733 tons, we then calculate a coefficient for each benefit endpoint to derive benefit transfer values for (1) incidence per ton reduced, and (2) benefit per ton reduced.

Table D-5(b) shows the results of phase two of the analysis associated with SO2 reductions. Using the benefit transfer values for incidence and value, we calculate the approximate benefits of the remaining 41,372 tons of SO2 out of the total 136,733 tons. Multiplying the total benefit per ton from Table D-5(a) of $22,071 to the 41,372 tons SO2 yields total benefits of the phase two analysis for SO2 of $913 million.

Tables D-6(a) and D-6(b) present results of the phase one and phase two analysis for the expected 569,229 tons of PM reduced due to the above the MACT floor regulatory option of the NESHAP. The phase one analysis of PM reductions (Table D-6(a)) results in total benefits of $7.9 billion for 313,947 tons of PM10 and 94,565 tons of PM2.5. The resulting total benefit transfer value is $83,647 per ton of PM. Applying the benefit transfer values to the remaining 255,282 tons of PM results in total phase two benefits of approximately $6.4 billion.

Tables D-7(a) and D-7(b) show the summary of results of the phase one and phase two analysis for the combination of SO2 and PM reductions. Then Table D-8 aggregates the results of the two phases for all pollutant reductions to provided an estimate of the total benefits of the Industrial Boilers/Process Heaters NESHAP under the above MACT floor regulatory option in 2005 equal to $17.2 billion.

Table D-1(a). Base Estimate: Results of Air Quality and Benefit Analyses for the Phase One Analysis of the Industrial Boilers/Process Heaters NESHAP MACT Floor in 2005 (SO2 reductions only)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$) Simple Mean	Income Adjustment Factor	Adjusted Benefits (millions 1999$)	National Benefit-Transfer Values: Incidence/ton	National Benefit-Transfer Values: $/ton (1999$)
MORTALITY							
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	241	$1,405	1.0805	$1,518	0.00292461	$18,385.89
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	241	$1,319	1.0805	$1,425	0.00292461	$17,269.44
CHRONIC ILLNESS							
Chronic Bronchitis	Schwartz, 1993	321	$106	1.0911	$115	0.00388893	$1,397.96
HOSPITALIZATION							
COPD-Related	Samet et al. (2000)	51	$1	1.0000	$1	0.00061787	$7.65
Pneumonia-Related	Samet et al. (2000)	62	$1	1.0000	$1	0.00075113	$11.04
Asthma-Related	Sheppard et al. (1999)	24	$0	1.0000	$0	0.00029076	$1.99
Cardiovascular-Related	Samet et al. (2000)	149	$3	1.0000	$3	0.00180514	$33.19
Asthma-Related ER Visits	Schwartz et al. (1993)	134	$0.0	1.0000	$0.0	0.00162342	$0.48
MINOR ILLNESS							
Acute Bronchitis	Dockery et al. (1996)	490	$0.0	1.0275	$0.0	0.00593637	$0.35
Upper Respiratory Symptoms	Pope et al. (1991)	12,976	$0.3	1.0275	$0.3	0.15720022	$3.91
Lower Respiratory Symptoms	Schwartz et al. (1994)	5,327	$0	1.0275	$0	0.06453591	$1.01
Asthma Attacks	Whittemore and Korn (1980)	11,120	B	1.0275	B	0.13471911	B
Work Loss Days	Ostro (1987)	42,611	$5	1.0000	$5	0.51623645	$54.72
MRAD - Adjusted	Ostro and Rothschild (1989)	214,592	$10	1.0275	$11	2.59979181	$129.42
WELFARE EFFECTS							
Visibility							
Recreational		Direct Economic Valuation	$0	1.1908	$0		$0.00
Total Base PM-Related Benefits, Discount Rate = 3%			**$1,530**		**$1,653**		$20,027.62
Total Base PM-Related Benefits, Discount Rate = 7%			**$1,445**		**$1,561**		$18,911.17

NOTE: Emission Reduction Summary (Converted from Mg to Tons)	
SO2 Emission Reductions modeled in SR Matrix & CAPMS	82542
Total SO2 Emission Reductions from all sources (MACT floor)	112936
SO2 reductions applied to benefit transfer values	30394

Table D-1(b). Base Estimate: Results of Benefit Transfer Application for the Phase Two Analysis of the Industrial Boilers/Process Heaters NESHAP MACT Floor in 2005 (SO2 reductions only)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$) Simple Mean	Income Adjustment Factor	Adjusted Benefits (millions 1999$)
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	89	$517	1.0805	$559
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	89	$486	1.0805	$525
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	118	$39	1.0911	$42
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	19	$0	1.0000	$0
Pneumonia-Related	Samet et al. (2000)	23	$0	1.0000	$0
Asthma-Related	Sheppard et al. (1999)	9	$0	1.0000	$0
Cardiovascular-Related	Samet et al. (2000)	55	$1	1.0000	$1
Asthma-Related ER Visits	Schwartz et al. (1993)	49	$0.0	1.0000	$0.0
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	180	$0.0	1.0275	$0.0
Upper Respiratory Symptoms	Pope et al. (1991)	4,778	$0.1	1.0275	$0.1
Lower Respiratory Symptoms	Schwartz et al. (1994)	1,962	$0	1.0275	$0
Asthma Attacks	Whittemore and Korn (1980)	4,095	B	1.0275	B
Work Loss Days	Ostro (1987)	15,690	$2	1.0000	$2
MRAD - Adjusted	Ostro and Rothschild (1989)	79,018	$4	1.0275	$4
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$563**		**$609**
Total Base PM-Related Benefits, Discount Rate = 7%			**$532**		**$575**

Table D-2(a). Base Estimate: Results of Air Quality and Benefit Analyses for the Phase One Analysis of the Industrial Boilers/Process Heaters NESHAP MACT Floor in 2005 (PM reductions only)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$) Simple Mean	Income Adjustment Factor	Adjusted Benefits	National Benefit-Transfer Values: Incidence/ton	National Benefit-Transfer Values: $/ton (1999$)
MORTALITY							
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	903	$5,254	1.0805	$5,677	0.01202477	$75,594.95
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	903	$4,935	1.0805	$5,332	0.01202477	$71,004.58
CHRONIC ILLNESS							
Chronic Bronchitis	Schwartz, 1993	2,356	$776	1.0911	$847	0.00888537	$3,194.03
HOSPITALIZATION							
COPD-Related	Samet et al. (2000)	417	$5	1.0000	$5	0.00157267	$19.47
Pneumonia-Related	Samet et al. (2000)	509	$7	1.0000	$7	0.00191963	$28.21
Asthma-Related	Sheppard et al. (1999)	90	$1	1.0000	$1	0.00119848	$8.21
Cardiovascular-Related	Samet et al. (2000)	1,229	$23	1.0000	$23	0.00463502	$85.22
Asthma-Related ER Visits	Schwartz et al. (1993)	949	$0.3	1.0000	$0.3	0.00357904	$1.07
MINOR ILLNESS							
Acute Bronchitis	Dockery et al. (1996)	1,866	$0.1	1.0275	$0.1	0.02484853	$1.46
Upper Respiratory Symptoms	Pope et al. (1991)	91,618	$2.2	1.0275	$2.3	0.34552721	$8.60
Lower Respiratory Symptoms	Schwartz et al. (1994)	20,369	$0	1.0275	$0	0.27124181	$4.26
Asthma Attacks	Whittemore and Korn (1980)	80,696	B	1.0275	B	0.30433468	B
Work Loss Days	Ostro (1987)	158,563	$17	1.0000	$17	2.11150235	$223.82
MRAD - Adjusted	Ostro and Rothschild (1989)	760,866	$37	1.0275	$38	10.13204793	$504.40
WELFARE EFFECTS							
Visibility							
Recreational		Direct Economic Valuation	$0	1.1908	$0		$0.00
Total Base PM-Related Benefits, Discount Rate = 3%			**$6,123**		**$6,617**		$88,118.38
Total Base PM-Related Benefits, Discount Rate = 7%			**$5,803**		**$6,273**		$83,528.02

NOTE: Emission Reduction Summary (Converted from Mg to Tons)

Industrial Boiler PM Reductions modeled in SR Matrix & CAPMS	265155
Process Heater PM Reductions modeled in SR Matrix & CAPMS	0
Total PM10 Reductions modeled in Phase One	265155
Total PM2.5 Reductions modeled in Phase One	75095
Total PM Reductions from All Sources (MACT floor)	562110
PM10 reductions applied to benefit transfer values	296955
Non-Inventory PM2.5 reductions applied to benefit transfer values	84101

Table D-2(b). Base Estimate: Results of Benefit Transfer Application for the Phase Two Analysis of the Industrial Boilers/Process Heaters NESHAP MACT Floor in 2005 (PM reductions only)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$)	Income Adjustment Factor	Adjusted Benefits
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	1,011	$5,884	1.0805	$6,358
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	1,011	$5,527	1.0805	$5,972
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	2,639	$869	1.0911	$948
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	467	$6	1.0000	$6
Pneumonia-Related	Samet et al. (2000)	570	$8	1.0000	$8
Asthma-Related	Sheppard et al. (1999)	101	$1	1.0000	$1
Cardiovascular-Related	Samet et al. (2000)	1,376	$25	1.0000	$25
Asthma-Related ER Visits	Schwartz et al. (1993)	1,063	$0.3	1.0000	$0.3
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	2,090	$0.1	1.0275	$0.1
Upper Respiratory Symptoms	Pope et al. (1991)	102,606	$2.5	1.0275	$2.6
Lower Respiratory Symptoms	Schwartz et al. (1994)	22,812	$0	1.0275	$0
Asthma Attacks	Whittemore and Korn (1980)	90,374	B	1.0275	B
Work Loss Days	Ostro (1987)	177,580	$19	1.0000	$19
MRAD - Adjusted	Ostro and Rothschild (1989)	852,117	$41	1.0275	$42
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$6,857**		**$7,411**
Total Base PM-Related Benefits, Discount Rate = 7%			**$6,499**		**$7,025**

Table D-3(a). Base Estimate: Results of Air Quality and Benefit Analyses for the Phase One Analysis of the Industrial Boilers/Process Heaters NESHAP MACT Floor in 2005 (PM and SO2 reductions modeled together)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$) Simple Mean	Income Adjustment Factor	Adjusted Benefits
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	1,165	$6,778	1.0805	$7,324
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	1,165	$6,367	1.0805	$6,879
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	2,344	$772	1.0911	$843
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	415	$5	1.0000	$5
Pneumonia-Related	Samet et al. (2000)	507	$7	1.0000	$7
Asthma-Related	Sheppard et al. (1999)	117	$1	1.0000	$1
Cardiovascular-Related	Samet et al. (2000)	1,225	$23	1.0000	$23
Asthma-Related ER Visits	Schwartz et al. (1993)	925	$0.3	1.0000	$0.3
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	2,425	$0.1	1.0275	$0.1
Upper Respiratory Symptoms	Pope et al. (1991)	89,477	$2.2	1.0275	$2.2
Lower Respiratory Symptoms	Schwartz et al. (1994)	26,465	$0	1.0275	$0
Asthma Attacks	Whittemore and Korn (1980)	79,018	B	1.0275	B
Work Loss Days	Ostro (1987)	205,400	$22	1.0000	$22
MRAD - Adjusted	Ostro and Rothschild (1989)	1,011,204	$49	1.0275	$50
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$7,660**		**$8,278**
Total Base PM-Related Benefits, Discount Rate = 7%			**$7,249**		**$7,833**

Table D-3(b). Base Estimate: Results of Benefit Transfer Application for the Phase Two Analysis of the Industrial Boilers/Process Heaters NESHAP MACT Floor in 2005 (PM and SO2 reductions)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$)	Income Adjustment Factor	Adjusted Benefits (millions 1999$)
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	1,100	$6,401	1.0805	$6,916
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	1,100	$6,012	1.0805	$6,496
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	2,757	$908	1.0911	$991
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	486	$6	1.0000	$6
Pneumonia-Related	Samet et al. (2000)	593	$9	1.0000	$9
Asthma-Related	Sheppard et al. (1999)	110	$1	1.0000	$1
Cardiovascular-Related	Samet et al. (2000)	1,431	$26	1.0000	$26
Asthma-Related ER Visits	Schwartz et al. (1993)	1,112	$0.3	1.0000	$0.3
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	2,270	$0.1	1.0275	$0.1
Upper Respiratory Symptoms	Pope et al. (1991)	107,384	$2.6	1.0275	$2.7
Lower Respiratory Symptoms	Schwartz et al. (1994)	24,773	$0	1.0275	$0
Asthma Attacks	Whittemore and Korn (1980)	94,468	B	1.0275	B
Work Loss Days	Ostro (1987)	193,270	$20	1.0000	$20
MRAD - Adjusted	Ostro and Rothschild (1989)	931,135	$45	1.0275	$46
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$7,420**		**$8,020**
Total Base PM-Related Benefits, Discount Rate = 7%			**$7,032**		**$7,600**

NOTE: Results of this table are based on the addition of incidences and monetary values from Tables D-1(b) and D-2(b).

Table D-4. Base Estimate: Total Benefits of the Industrial Boilers/Process Heaters NESHAP - MACT Floor in 2005
(Combined Estimates of Reduced Incidences and Monetized Benefits from Phase One and Two Analyses)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$)	Income Adjustment Factor	Adjusted Benefits (millions 1999$)
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	2,265	$13,179	1.0805	$14,240
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	2,265	$12,379	1.0805	$13,376
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	5,101	$1,680	1.0911	$1,834
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	901	$11	1.0000	$11
Pneumonia-Related	Samet et al. (2000)	1,100	$16	1.0000	$16
Asthma-Related	Sheppard et al. (1999)	227	$2	1.0000	$2
Cardiovascular-Related	Samet et al. (2000)	2,656	$49	1.0000	$49
Asthma-Related ER Visits	Schwartz et al. (1993)	2,037	$0.6	1.0000	$0.6
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	4,695	$0.3	1.0275	$0.3
Upper Respiratory Symptoms	Pope et al. (1991)	196,861	$4.8	1.0275	$4.9
Lower Respiratory Symptoms	Schwartz et al. (1994)	51,238	$1	1.0275	$1
Asthma Attacks	Whittemore and Korn (1980)	173,486	B	1.0275	B
Work Loss Days	Ostro (1987)	398,671	$42	1.0000	$42
MRAD - Adjusted	Ostro and Rothschild (1989)	1,942,339	$94	1.0275	$97
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$15,080**		**$16,297**
Total Base PM-Related Benefits, Discount Rate = 7%			**$14,280**		**$15,432**

NOTE: Results of this table are based on the addition of results from Tables D-3(a) and D-3(b).

Table D-5(a). Base Estimate: Results of Air Quality and Benefit Analyses for the Phase One Analysis of the Industrial Boilers/Process Heaters NESHAP Above the MACT Floor in 2005 (SO2 reductions only)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$) Simple Mean	Income Adjustment Factor	Adjusted Benefits (millions 1999$)	National Benefit-Transfer Values: Incidence/ton	National Benefit-Transfer Values: $/ton (1999$)
MORTALITY							
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	308	$1,792	1.0805	$1,936	0.00322983	$20,304.67
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	308	$1,683	1.0805	$1,819	0.00322983	$19,071.71
CHRONIC ILLNESS							
Chronic Bronchitis	Schwartz, 1993	398	$131	1.0911	$143	0.00417361	$1,500.29
HOSPITALIZATION							
COPD-Related	Samet et al. (2000)	58	$1	1.0000	$1	0.00060822	$7.53
Pneumonia-Related	Samet et al. (2000)	71	$1	1.0000	$1	0.00074454	$10.94
Asthma-Related	Sheppard et al. (1999)	31	$0	1.0000	$0	0.00032508	$2.23
Cardiovascular-Related	Samet et al. (2000)	170	$3	1.0000	$3	0.00178270	$32.78
Asthma-Related ER Visits	Schwartz et al. (1993)	147	$0.0	1.0000	$0.0	0.00154151	$0.46
MINOR ILLNESS							
Acute Bronchitis	Dockery et al. (1996)	657	$0.0	1.0275	$0.0	0.00688919	$0.41
Upper Respiratory Symptoms	Pope et al. (1991)	14,162	$0.3	1.0275	$0.4	0.14851322	$3.70
Lower Respiratory Symptoms	Schwartz et al. (1994)	7,174	$0	1.0275	$0	0.07523289	$1.18
Asthma Attacks	Whittemore and Korn (1980)	12,248	B	1.0275	B	0.12844191	B
Work Loss Days	Ostro (1987)	54,979	$6	1.0000	$6	0.57653799	$61.11
MRAD - Adjusted	Ostro and Rothschild (1989)	279,759	$14	1.0275	$14	2.93367993	$146.05
WELFARE EFFECTS							
Visibility							
Recreational		Direct Economic Valuation	$0	1.1908	$0		$0.00
Total Base PM-Related Benefits, Discount Rate = 3%			**$1,948**		**$2,105**		$22,071.34
Total Base PM-Related Benefits, Discount Rate = 7%			**$1,839**		**$1,987**		$20,838.38

NOTE: Emission Reduction Summary (Converted from Mg to Tons)

SO2 Emission Reductions modeled in SR Matrix & CAPMS	95361
Total SO2 Reductions from all sources (Above MACT Floor)	136733.3
SO2 reductions applied to benefit transfer values	41372.3

Table D-5(b). Base Estimate: Results of Benefit Transfer Application for the Phase Two Analysis of the Industrial Boilers/Process Heaters NESHAP Above the MACT Floor in 2005 (SO2 reductions only)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$) Simple Mean	Income Adjustment Factor	Adjusted Benefits (millions 1999$)
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	134	$777	1.0805	$840
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	134	$730	1.0805	$789
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	173	$57	1.0911	$62
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	25	$0	1.0000	$0
Pneumonia-Related	Samet et al. (2000)	31	$0	1.0000	$0
Asthma-Related	Sheppard et al. (1999)	13	$0	1.0000	$0
Cardiovascular-Related	Samet et al. (2000)	74	$1	1.0000	$1
Asthma-Related ER Visits	Schwartz et al. (1993)	64	$0.0	1.0000	$0.0
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	285	$0.0	1.0275	$0.0
Upper Respiratory Symptoms	Pope et al. (1991)	6,144	$0.1	1.0275	$0.2
Lower Respiratory Symptoms	Schwartz et al. (1994)	3,113	$0	1.0275	$0
Asthma Attacks	Whittemore and Korn (1980)	5,314	B	1.0275	B
Work Loss Days	Ostro (1987)	23,853	$3	1.0000	$3
MRAD - Adjusted	Ostro and Rothschild (1989)	121,373	$6	1.0275	$6
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$845**		**$913**
Total Base PM-Related Benefits, Discount Rate = 7%			**$798**		**$862**

Table D-6(a). Base Estimate: Results of Air Quality and Benefit Analyses for the Phase One Analysis of the Industrial Boilers/Process Heaters NESHAP Above the MACT Floor in 2005 (PM reductions only)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$) Simple Mean	Income Adjustment Factor	Adjusted Benefits	National Benefit-Transfer Values: Incidence/ton	National Benefit-Transfer Values: $/ton (1999$)
MORTALITY							
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	1,087	$6,327	1.0805	$6,836	0.01149862	$72,287.27
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	1,087	$5,942	1.0805	$6,421	0.01149862	$67,897.76
CHRONIC ILLNESS							
Chronic Bronchitis	Schwartz, 1993	2,683	$884	1.0911	$964	0.00854575	$3,071.95
HOSPITALIZATION							
COPD-Related	Samet et al. (2000)	470	$6	1.0000	$6	0.00149707	$18.53
Pneumonia-Related	Samet et al. (2000)	573	$8	1.0000	$8	0.00182515	$26.82
Asthma-Related	Sheppard et al. (1999)	109	$1	1.0000	$1	0.00115265	$7.89
Cardiovascular-Related	Samet et al. (2000)	1,385	$25	1.0000	$25	0.00441157	$81.12
Asthma-Related ER Visits	Schwartz et al. (1993)	1070	$0.3	1.0000	$0.3	0.00340822	$1.02
MINOR ILLNESS							
Acute Bronchitis	Dockery et al. (1996)	2,230	$0.1	1.0275	$0.1	0.02358633	$1.39
Upper Respiratory Symptoms	Pope et al. (1991)	103,400	$2.5	1.0275	$2.6	0.32935392	$8.20
Lower Respiratory Symptoms	Schwartz et al. (1994)	24,325	$0	1.0275	$0	0.25722847	$4.04
Asthma Attacks	Whittemore and Korn (1980)	90,940	B	1.0275	B	0.28966831	B
Work Loss Days	Ostro (1987)	190,370	$20	1.0000	$20	2.01311570	$213.39
MRAD - Adjusted	Ostro and Rothschild (1989)	918,645	$45	1.0275	$46	9.71442399	$483.61
WELFARE EFFECTS							
Visibility							
Recreational		Direct Economic Valuation	$0	1.1908	$0		$0.00
Total Base PM-Related Benefits, Discount Rate = 3%			**$7,319**		**$7,910**		$83,646.62
Total Base PM-Related Benefits, Discount Rate = 7%			**$6,935**		**$7,495**		$79,257.11

NOTE: Emission Reduction Summary (Converted from Mg to Tons)

Industrial Boiler PM Reductions modeled in SR Matrix & CAPMS	295645
Process Heater PM Reductions modeled in SR Matrix & CAPMS	18302
Total PM10 Reductions modeled	**313947**
Total PM2.5 Reductions modeled	**94565**
Total PM Reductions from All Sources (Above MACT Floor)	569229.1
PM10 reductions applied to benefit transfer values	255282.1
PM2.5 reductions applied to benefit transfer values	76894

Table D-6(b). Base Estimate: Results of Benefit Transfer Application for the Phase Two Analysis of the Industrial Boilers/Process Heaters NESHAP Above the MACT Floor in 2005 (PM reductions only)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$)	Income Adjustment Factor	Adjusted Benefits
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	884	$5,144	1.0805	$5,558
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	884	$4,832	1.0805	$5,221
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	2,182	$719	1.0911	$784
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	382	$5	1.0000	$5
Pneumonia-Related	Samet et al. (2000)	466	$7	1.0000	$7
Asthma-Related	Sheppard et al. (1999)	89	$1	1.0000	$1
Cardiovascular-Related	Samet et al. (2000)	1,126	$21	1.0000	$21
Asthma-Related ER Visits	Schwartz et al. (1993)	870	$0.3	1.0000	$0.3
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	1,814	$0.1	1.0275	$0.1
Upper Respiratory Symptoms	Pope et al. (1991)	84,078	$2.0	1.0275	$2.1
Lower Respiratory Symptoms	Schwartz et al. (1994)	19,779	$0	1.0275	$0
Asthma Attacks	Whittemore and Korn (1980)	73,947	B	1.0275	B
Work Loss Days	Ostro (1987)	154,797	$16	1.0000	$16
MRAD - Adjusted	Ostro and Rothschild (1989)	746,984	$36	1.0275	$37
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$5,951**		**$6,432**
Total Base PM-Related Benefits, Discount Rate = 7%			**$5,639**		**$6,094**

Table D-7(a). Base Estimate: Results of Air Quality and Benefit Analyses for the Phase One Analysis of the Industrial Boilers/Process Heaters NESHAP Above the MACT Floor in 2005 (PM and SO2 reductions modeled together)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$) Simple Mean	Income Adjustment Factor	Adjusted Benefits
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	1,390	$8,086	1.0805	$8,737
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	1,390	$7,595	1.0805	$8,207
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	2,864	$944	1.0911	$1,029
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	502	$6	1.0000	$6
Pneumonia-Related	Samet et al. (2000)	613	$9	1.0000	$9
Asthma-Related	Sheppard et al. (1999)	139	$1	1.0000	$1
Cardiovascular-Related	Samet et al. (2000)	1,480	$27	1.0000	$27
Asthma-Related ER Visits	Schwartz et al. (1993)	1142	$0.3	1.0000	$0.3
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	2,869	$0.2	1.0275	$0.2
Upper Respiratory Symptoms	Pope et al. (1991)	110,367	$2.7	1.0275	$2.7
Lower Respiratory Symptoms	Schwartz et al. (1994)	31,293	$0	1.0275	$0
Asthma Attacks	Whittemore and Korn (1980)	97,058	$4	1.0275	$4
Work Loss Days	Ostro (1987)	243,866	$26	1.0000	$26
MRAD - Adjusted	Ostro and Rothschild (1989)	1,196,497	$58	1.0275	$60
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$9,165**		**$9,904**
Total Base PM-Related Benefits, Discount Rate = 7%			**$8,674**		**$9,373**

Table D-7(b). Base Estimate: Results of Benefit Transfer Application for the Phase Two Analysis of the Industrial Boilers/Process Heaters NESHAP Above the MACT Floor in 2005 (PM and SO2 reductions)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$)	Income Adjustment Factor	Adjusted Benefits (millions 1999$)
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	1,018	$5,922	1.0805	$6,399
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	1,018	$5,562	1.0805	$6,010
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	2,354	$776	1.0911	$846
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	407	$5	1.0000	$5
Pneumonia-Related	Samet et al. (2000)	497	$7	1.0000	$7
Asthma-Related	Sheppard et al. (1999)	102	$1	1.0000	$1
Cardiovascular-Related	Samet et al. (2000)	1,200	$22	1.0000	$22
Asthma-Related ER Visits	Schwartz et al. (1993)	934	$0.3	1.0000	$0.3
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	2,099	$0.1	1.0275	$0.1
Upper Respiratory Symptoms	Pope et al. (1991)	90,222	$2.2	1.0275	$2.2
Lower Respiratory Symptoms	Schwartz et al. (1994)	22,892	$0	1.0275	$0
Asthma Attacks	Whittemore and Korn (1980)	79,261	$3	1.0275	$3
Work Loss Days	Ostro (1987)	178,650	$19	1.0000	$19
MRAD - Adjusted	Ostro and Rothschild (1989)	868,357	$42	1.0275	$43
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$6,800**		**$7,348**
Total Base PM-Related Benefits, Discount Rate = 7%			**$6,440**		**$6,960**

NOTE: Results of this table are based on the addition of incidences and monetary values from Tables D-5(b) and D-6(b).

Table D-8. Base Estimate: Total Benefits of the Industrial Boilers/Process Heaters NESHAP - Above the MACT Floor in 2005
(Combined Estimates of Reduced Incidences and Monetized Benefits from Phase One and Two Analyses)

Endpoint	Reference	Avoided Incidence (cases/year) Mean	Monetary Benefits (millions 1999$)	Income Adjustment Factor	Adjusted Benefits (millions 1999$)
MORTALITY					
Ages 30+, Mean, Discount Rate = 3%	Krewski et al. (2000)	2,408	$14,008	1.0805	$15,136
Ages 30+, Mean, Discount Rate = 7%	Krewski et al. (2000)	2,408	$13,158	1.0805	$14,217
CHRONIC ILLNESS					
Chronic Bronchitis	Schwartz, 1993	5,218	$1,719	1.0911	$1,876
HOSPITALIZATION					
COPD-Related	Samet et al. (2000)	909	$11	1.0000	$11
Pneumonia-Related	Samet et al. (2000)	1,110	$16	1.0000	$16
Asthma-Related	Sheppard et al. (1999)	241	$2	1.0000	$2
Cardiovascular-Related	Samet et al. (2000)	2,680	$49	1.0000	$49
Asthma-Related ER Visits	Schwartz et al. (1993)	2,076	$0.6	1.0000	$0.6
MINOR ILLNESS					
Acute Bronchitis	Dockery et al. (1996)	4,968	$0.3	1.0275	$0.3
Upper Respiratory Symptoms	Pope et al. (1991)	200,589	$4.9	1.0275	$5.0
Lower Respiratory Symptoms	Schwartz et al. (1994)	54,185	$1	1.0275	$1
Asthma Attacks	Whittemore and Korn (1980)	82,130	B	1.0275	B
Work Loss Days	Ostro (1987)	275,708	$29	1.0000	$29
MRAD - Adjusted	Ostro and Rothschild (1989)	2,064,854	$100	1.0275	$103
WELFARE EFFECTS					
Visibility					
Recreational		Direct Economic Valuation	$0	1.1908	$0
Total Base PM-Related Benefits, Discount Rate = 3%			**$15,942**		**$17,229**
Total Base PM-Related Benefits, Discount Rate = 7%			**$15,091**		**$16,310**

NOTE: Results of this table are based on the addition of results from Tables D-7(a) and D-7(b).

Appendix E. Impacts Based on Low-Risk Threshold Cutoffs for Hydrochloric Acid (HCl) and Manganese (Mn)

Background

Among the alternatives to compliance with the final rule are health-based threshold cutoffs for different pollutants. As an alternative to the requirement for each large solid fuel-fired boiler to demonstrate compliance with the HCl emission limit in the final rule, you may demonstrate compliance with a health-based HCl equivalent allowable emission limit. In lieu of complying with the emission standard for total selected metals (TSM) in the final rule based on the sum of emissions for the eight selected metals, you may demonstrate eligibility for complying with the TSM standard based on excluding manganese emissions from the summation of TSM emissions for the affected source unit(s).

Emission Reductions

Nationwide emissions of selected HAP (i.e., HCl, hydrogen fluoride, lead, and nickel) will be reduced by 58,500 tpy for existing units and 73 tpy for new units. Depending on the number of facilities demonstrating eligibility for the health-based compliance alternatives, the total HAP reduction for existing units could be 50,600 tpy. Emissions of HCl will be reduced by 42,000 tpy for existing units and 72 tpy for new units. Depending on the number of facilities demonstrating eligibility for the health-based compliance alternatives, the total HCl emissions reduction for existing units could be 36,400 tpy. Emissions of mercury will be reduced by 1.9 tpy for existing units and 0.006 tpy for new units. Emissions of PM will be reduced by 565,000 tpy for existing units and 480 tpy for new units. Depending on the number of facilities demonstrating eligibility for the health-based compliance alternatives, the total PM emissions reduction for existing units could be 547,000 tpy. Emissions of total selected nonmercury metals (i.e., arsenic, beryllium, cadmium, chromium, lead, manganese, nickel, and selenium) will be reduced by 1,100 tpy for existing units and will be reduced by 1.4 tpy for new units. Depending on the number of facilities demonstrating eligibility for the health-based compliance alternatives, the total nonmercury metals emissions reduction for existing units could fall to be 950 tpy. In addition, emissions of sulfur dioxide are established to be reduced by 113,000 tpy for existing sources and 110 tpy for new sources. Depending on the number of facilities demonstrating eligibility for the health-based compliance alternatives, the total sulfur dioxide emissions reduction for existing units could fall to be 49,000 tpy.

A discussion of the methodology used to estimate emissions and emissions reductions is presented in “Estimation of Baseline Emissions and Emissions Reductions for Industrial, Commercial, and Institutional Boilers and Process Heaters” in the docket. To estimate the potential impacts of the health-based compliance alternatives, we performed a preliminary “rough” assessment of the large solid fuel subcategory to determine the extent to which facilities might become eligible for the health-based compliance alternatives. Based on the results of this rough assessment, 448 coal-fired boilers could potentially be eligible for the HCl compliance alternative and 386 biomass-fired boilers could be potentially eligible for the TSM compliance alternative.

Wastewater and Solid Waste impacts

The EPA estimates the additional water usage that would result from the MACT floor level of control to be 110 million gallons per year for existing sources and 0.6 million gallons per year for new sources. In addition to the increased water usage, an additional 3.7 million gallons per year of wastewater will be produced for existing sources and 0.6 million gallons per year for new sources. The costs of treating the additional wastewater are $18,000 for existing sources and $2,300 for new sources, in advance of any facility demonstrating eligibility for the health-based compliance alternatives. These costs are accounted for in the control costs estimates.

The EPA estimates the additional solid waste that would result from the MACT floor level of control to be 102,000 tpy for existing sources and 1 tpy for new sources. The estimated costs of handling the additional solid waste generated are $1.5 million for existing sources and $17,000 for new sources, in advance of any facility demonstrating eligibility for the health-based compliance alternatives. These costs are also accounted for in the control costs estimates.

A discussion of the methodology used to estimate impacts is presented in “Estimation of Impacts for Industrial, Commercial, and Institutional Boilers and Process Heaters NESHAP” in the docket.

Energy Impact from Additional Control Equipment

The EPA expects an increase of approximately 1,130 million kilowatt hours (kWh) in national annual energy usage as a result of the final rule, in advance of any facility demonstrating eligibility for the health-based compliance alternatives. Of this amount, 1,120 million kWh is estimated from existing sources and 13 million kWh is estimated from new sources. The increase results from the electricity required to operate control devices installed to meet the final rule, such as wet scrubbers and fabric filters.

Compliance Costs

To estimate the national cost impacts of the final rule for existing sources, EPA developed several model boilers and process heaters and determined the cost of control equipment for these model boilers. The EPA assigned a model boiler or heater to each existing unit in the database based on the fuel, size, design, and current controls. The analysis considered all air pollution control equipment currently in operation at existing boilers and process heaters. Model costs were then assigned to all existing units that could not otherwise meet the proposed emission limits. The resulting total national cost impact of the final rule is $1,790 million in capital expenditures and $860 million per year in total annual costs. Depending on the number of facilities demonstrating eligibility for the health-based compliance alternatives, these costs could fall to be $1,440 million in capital expenditures and $690 million per year in total annual costs. The total capital and annual costs include costs for testing, monitoring, and recordkeeping and reporting.- Costs include testing and monitoring costs, but not recordkeeping and reporting costs.Using Department of Energy projections on fuel expenditures, EPA estimated the number of additional boilers that could be potentially constructed. The resulting total national cost impact of the final rule in the 5th year is $58 million in capital expenditures and $18.6 million per year in total annual costs, in advance of any facility demonstrating eligibility for the health-based provisions. Costs are mainly for testing and monitoring.

A discussion of the methodology used to estimate cost impacts is presented in "Methodology and Results of Estimating the Cost of Complying with the Industrial, Commercial, and Institutional Boiler and Process Heater NESHAP" in the docket.

Economic Impacts

The economic impact analysis shows that the expected price increase for output in the 40 affected industries would be no more than 0.04 percent as a result of the final rule for industrial boilers and process heaters. The expected change in production of affected output is a reduction of only 0.03 percent or less in the same industries. In addition, impacts to affected energy markets show that prices of petroleum, natural gas, electricity and coal should increase by no more than 0.05 percent as a result of implementation of the final rule, and output of these types of energy should decrease by no more than 0.01 percent. These impacts are generated in advance of any facility demonstrating eligibility for the health-based compliance alternatives. Depending on the number of affected facilities demonstrating eligibility for the health-based compliance alternatives, these impacts on product prices could fall to a 0.03 percent increase, and a decrease in output of the energy types mentioned previously of less than 0.01 percent. Therefore, it is likely that there is no adverse impact expected to occur for those industries that produce output affected by the final rule, such as lumber and wood products, chemical manufacturers, petroleum refining, and furniture manufacturing.

Small Entity Impacts

After considering the economic impact of the final rule on small entities, we have determined that the final rule will not have a significant economic impact on a substantial number of small entities. Based on SBA size definitions for the affected industries and reported sales and employment data, EPA identified 185 of the 576 entities, or 32 percent, owning affected facilities as small entities. Although small entities represent 32 percent of the entities within the source category, they are expected to incur only 4 percent of the total compliance costs of $862.7 million (1999 dollars). There are only ten small entities with compliance costs equal to or greater than 3 percent of their sales. In addition, there are only 24 small entities with cost-to-sales ratios between 1 and 3 percent.

An economic impact analysis was performed to estimate the changes in product price and production quantities for the final rule. As mentioned in the summary of economic impacts earlier in this preamble, the estimated changes in prices and output for affected entities is no more than 0.05 percent.

For more information, consult the docket for the final rule.

It should be noted that these small entity impacts are in advance of any facility demonstrating eligibility for the health-based compliance alternatives. Depending on the number of affected facilities demonstrating eligibility for the health-based compliance alternatives, the estimated small entity impacts fall to eight small entities with compliance costs equal to or greater than 3 percent of their sales, and 14 small entities with compliance costs between 1 and 3 percent of their sales.

The final rule will not have a significant economic impact on a substantial number of small entities as a result of several decisions EPA made regarding the development of the rule, which resulted in limiting the impact of the rule on small entities. First, as mentioned earlier in this preamble, EPA identified small units (heat input of 10 MMBtu/hr or less) and limited use boilers (operate less than 10 percent of the time) as separate subcategories different from large units. Many small and limited use units are located at small entities. As also discussed earlier, the results of the MACT floor analysis for these subcategories of existing sources was that no MACT floor could be identified except for the limited use solid fuel subcategory, which is less stringent than the MACT floor for large units. Furthermore, the results of the beyond-the-floor analysis for these subcategories indicated that the costs would be too high to consider them feasible options. Consequently, the final rule contains no emission limitations for any of the existing small and limited use subcategories except the existing limited use solid fuel subcategory. In addition, the alternative metals emission limit resulted in minimizing the impacts on small entities since some of the potential entities burning a fuel containing very little metals are small entities.

Social Costs and Benefits

The regulatory impact analysis prepared for the final rule including the EPA's assessment of costs and benefits, is detailed in the "Regulatory Impact Analysis for the Industrial Boilers and Process Heaters MACT" in the docket. Based on estimated compliance costs associated with the final rule and the predicted change in prices and production in the affected industries, the estimated social costs of the final rule are $863 million (1999 dollars). Depending on the number of affected facilities demonstrating eligibility for the health-based compliance alternatives, these annualized social costs could fall to $746 million.

It is estimated that 5 years after implementation of the final rule, HAP will be reduced by 58,500 tpy due to reductions in arsenic, beryllium, dioxin, hydrochloric acid, and several other HAP from industrial boilers and process heaters. Studies have determined a relationship between exposure to these HAP and the onset of cancer, however, there are some questions remaining on how cancers that may result from exposure to these HAP can be quantified in terms of dollars. Therefore, the EPA is unable to provide a monetized estimate of the benefits of the HAP reduced by the final rule at this time. However, there are significant reductions in PM and in SO_2 that occur. Reductions of 560,000 tons of PM with a diameter of less than or equal to 10 micrometers (PM_{10}), 159,000 tons of PM with a diameter of less than or equal to 2.5 micrometers ($PM_{2.5}$), and 112,000 tons of SO_2 are expected to occur. These reductions occur from existing sources in operation 5 years after the implementation of the regulation and are expected to continue throughout the life of the affected sources. The major health effect that results from these PM and SO_2 emissions reductions is a reduction in premature mortality. Other health effects that occur are reductions in chronic bronchitis, asthma attacks, and work-lost days (i.e., days when employees are unable to work).

While we are unable to monetize the benefits associated with the HAP emissions reductions, we are able to monetize the benefits associated with the PM and SO_2 emissions reductions. For SO_2 and PM, we estimated the benefits associated with health effects of PM, but were unable to quantify all categories of benefits (particularly those associated with ecosystem and environmental effects). Unquantified benefits are noted with "B" in the estimates presented below. Our primary estimate of the monetized benefits in 2005 associated with the implementation of the proposed alternative is $16.3 billion + B (1999 dollars). This estimate is about $15.3 billion + B (1999 dollars) higher than the estimated social costs shown earlier in this section. These benefit estimates are in advance of any facility demonstrating eligibility for the health-based compliance alternatives. Depending on the number of affected facilities demonstrating eligibility for the health-based compliance alternatives, the benefit estimate presuming the health-based compliance alternatives is $14.5 billion + B, which is $1.7 billion lower than the estimate for the final rule. This estimate is $13.8 billion + B higher than the estimated social costs presuming the health-based compliance alternatives. The general approach to calculating monetized benefits is discussed in more detail earlier in this preamble. For more detailed information on the benefits estimated for the final rule, refer to the RIA in the docket.

Energy Impact Analysis

As mentioned in the economic impact analysis, the reduction in petroleum product output, which includes reductions in fuel production, is estimated at only 0.001 percent, or about 68 barrels per day based on 2000 U.S. fuel production nationwide. That is a minimal reduction in nationwide petroleum product output. The reduction in coal production is estimated at only 0.014 percent, or about 3.5 million tpy (or less than 1,000 tons per day) based on 2000 U.S. coal production nationwide. The combination of the increase in electricity usage estimated with the effect of the increased price of affected output yields an increase in electricity output estimated at only 0.012 percent, or about 0.72 billion kilowatt-hours per year based on 2000 U.S. electricity production nationwide. All energy price changes estimated show no increase in price more than 0.05 percent nationwide, and a similar result occurs for energy distribution costs. We also expect that there will be no discernable impact on the import of foreign energy supplies, and no other adverse outcomes are expected to occur with regards to energy supplies. All of the results presented above account for the pass through of costs to consumers, as well as the cost impact to producers. For more information on the estimated energy effects, please refer to the economic impact analysis for the final rule.

Depending on the number of affected facilities demonstrating eligibility for the health-based compliance alternatives, the reduction in petroleum product output, which includes reductions in fuel production, could fall to 65 barrels per day, or only 0.001 percent.The reduction in coal production could fall to only 0.010 percent, or about 2.5 million tpy based on 2000 U.S. coal production nationwide. The combination of the increase in electricity usage estimated with the effect of the increased price of affected output could yield an increase in electricity output that could be only 0.0067 percent, or about 0.40 billion kilowatt-hours per year based on 2000 U.S. electricity production nationwide. All energy price changes estimated could now fall to increases of no more than 0.04 percent nationwide, and a similar result occurs for energy distribution costs. There should be no discernable impact on import of foreign energy supplies, and no other adverse outcomes are expected to occur with regards to energy supplies. All of the results presented with presumption of the health-based compliance alternatives also account for the pass through of costs to consumers as well as the cost impact to producers.

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